PROCEEDINGS

OF

THE AMERICAN ASSOCIATION

FOR THE

ADVANCEMENT OF SCIENCE.

TWENTY-SECOND MEETING,

HELD AT

PORTLAND, MAINE,

AUGUST, 1873.

SALEM:
PUBLISHED BY THE PERMANENT SECRETARY.
1874.

EDITED BY

F. W. PUTNAM,

Permanent Secretary.

PRINTED AT

THE SALEM PRESS,

SALEM, MASS.

TABLE OF CONTENTS.

COMMUNICATIONS.

A. MATHEMATICS, PHYSICS AND CHEMISTRY.

I. MATHEMATICS.

II. ASTRONOMY.

III. PHYSICS.

IV. PHYSICS OF THE GLOBE.

V. CHEMISTRY.

VI. MECHANICS.

TITLES

B. NATURAL HISTORY.

I. GEOLOGY.

II. PALEONTOLOGY.

III. BOTANY.

IV. ZOOLOGY.

V. ANTHROPOLOGY.

VI. PRACTICAL SCIENCE.

TITLES

EXECUTIVE PROCEEDINGS.

HISTORY OF THE MEETING.

OFFICERS

OF

THE PORTLAND MEETING.

PRESIDENT.

Joseph Lovering, of Cambridge.

VICE-PRESIDENT.

A. H. Worthen,* of Springfield, Ill.

PERMANENT SECRETARY.

F. W. Putnam, of Salem.

GENERAL SECRETARY.

C. A. White, of Brunswick, Me.

TREASURER.

W. S. Vaux, of Philadelphia.

STANDING COMMITTEE.

EX-OFFICIO.

Joseph Lovering, A. H. Worthen,* F. W. Putnam,
C. A. White, W. S. Vaux,
J. Lawrence Smith,* Alexander Winchell,* E. S. Morse,

AS CHAIRMEN OF THE SECTIONAL COMMITTEES.

Alexis Caswell, John L. LeConte.

FROM THE ASSOCIATION AT LARGE.

S. F. Baird, of Washington,
James Hall, of Albany,
J. E. Hilgard, of Washington,
Thomas Hill, of Portland,
T. Sterry Hunt, of Boston,
C. A. Young, of Hanover.

* Not present.

OFFICERS OF THE SECTIONS.

SECTION A.

ALEXIS CASWELL, of Providence, and THOS. HILL, of Portland, *Chairmen*.*
G. W. HOUGH, of Albany, *Secretary*.

SECTIONAL COMMITTEE.

C. A. YOUNG, of Hanover, N. H., E. B. ELLIOTT, of Washington,
W. W. WHEILDON, of Concord, Mass.

SUB-SECTION OF SECTION A.

Organized on the 6th day.
H. F. WALLING, of Boston, *Chairman*.
R. B. WARDER, of Cleves, Ohio, *Secretary*.

SECTION B.

JOHN L. LECONTE, of Philadelphia, *Chairman*.
SAMUEL H. SCUDDER, of Cambridge, *Secretary*.

SECTIONAL COMMITTEE.

F. B. HOUGH, of Lowville, N. Y. A. E. VERRILL, of New Haven.
THEODORE GILL, of Washington.

SUB-SECTION 1 OF SECTION B.

Organized on the 4th day.
J. G. MORRIS, of Baltimore, *Chairman*.
A. R. GROTE, of Buffalo, *Secretary*.

SUB-SECTION 2 OF SECTION B.

Organized on the 4th day.
T. STERRY HUNT, of Boston, *Chairman*.
W. H. NILES, of Cambridge, *Secretary*.

* Prof. Caswell was chairman until Saturday, and Dr. Hill held the office for the rest of the meeting.

LOCAL COMMITTEE.

Chairman:—Hon. BENJAMIN KINGSBURY, Jr.
Treasurer:—GEO. E. B. JACKSON, Esq.
Secretary:—Rev. CHARLES W. HAYES.

LOCAL SUB-COMMITTEES.

On Reception:—The Chairman and Secretary of the Local Committee *ex officio*; Geo. T. Davis, Nathan Cleaves, Geo. F. Emery, William Deering, I. Washburn, Jr., Francis Fessenden, Wm. L. Putnam, H. N. Jose, Rev. W. B. Hayden, Geo. E. B. Jackson, Geo. F. Shepley, Cyrus H. Farley, Rt. Rev. H. A. Neely.

On Rooms and Microscopists:—A. H. Waite, Nathan Webb, Dr. Wm. Wood, J. P. Thompson, C. B. Fuller, J. M. Gould, W N. Gould, Dr. Fred H. Gerrish.

On Finance:—Geo. E. B. Jackson, Treasurer of Local Committee *ex officio*; T. C. Hersey, Chairman; J. B. Brown, A. K. Shurtleff, Rufus E. Wood.

On Subscriptions:—F. N. Dow, Chairman; S. E. Spring, James H. Smith, Thos. A. Roberts, John M. Gould, H. H. Burgess, W. F. Milliken, Francis K. Swan, W. S. Jordan, Geo. S. Hunt, Frank Noyes, M. N. Rich, Charles E. Jose, J. S. Marrett, William Senter, Wm. W. Thomas, Jr., Franklin Fox, John Marshall Brown, William Allen.

On Excursions:—H. F. Furbish, Lewis B. Smith, James E. Carter, William A. Winship, Prentiss Loring, William R. Wood, Charles H. Haskell, Wm. E. Wood, W. S. Dana, Prof. Hitchcock.

On Printing:—Secretary of the Local Committee, *ex officio*; A. P. Stone, Geo. F. Talbot, James E. Prindle.

On Railroad and Steamboat Facilities:—Samuel J. Anderson, Francis Chase, Payson Tucker, John Porteous, T. C. Hersey, Geo. P. Wescott, J. B. Coyle, John Lynch, Josiah H. Drummond, J. S. Winslow, W. W. Harris.

On Mail and Telegraph:—C. W. Goddard, Stephen Berry, J. S. Bedlow, and the Secretary of the Local Committee, *ex officio*.

LOCAL COMMITTEE OF SUPERVISION.

Chairman:—Hon. GEORGE P. WESCOTT, Mayor of Portland.
Vice Chairman:—Hon. BENJAMIN KINGSBURY, Jr.
Treasurer:—GEO. E. B. JACKSON, Esq.
Secretary:—Rev. CHAS. W. HAYES.
Members:—The Chairmen of the several sub-committees.

SPECIAL COMMITTEES.

A. COMMITTEES CONTINUED FROM FORMER MEETINGS.

1. *Committee to Report in Relation to Uniform Standards in Weights, Measures and Coinage.*

F. A. P. BARNARD, of New York,
WALCOTT GIBBS,
B. A. GOULD, of Cambridge,
JOSEPH HENRY, of Washington,
J. E. HILGARD, of Washington,
JOHN LECONTE,
H. A. NEWTON, of New Haven,
BENJAMIN PEIRCE, of Cambridge,
W. B. ROGERS, of Boston,
J. LAWRENCE SMITH, Louisville.
E. B. ELLIOTT, of Washington.

2. *Committee to Memorialize the Legislature of New York for a New Survey of Niagara Falls.*

F. A. P. BARNARD, of New York,
CHARLES P. DALY,
JAMES HALL, of Albany,
WILLIAM E. LOGAN, of Montreal,
G. W. HOLLEY, of Niagara Falls.

3. *Committee to Report on the Best Methods of Organizing and Conducting State Geological Surveys.*

G. C. SWALLOW, of Columbia, Mo.,
JAMES HALL, of Albany,
J. S. NEWBERRY, of Cleveland,
ALEXANDER WINCHELL, Syracuse,
T. STERRY HUNT, of Boston,
BENJAMIN PEIRCE, of Cambridge.

4. *Committee to Memorialize Congress in relation to a Geological Map of the United States.*

This committee consists of such of the State Geologists as will join in the memorial.

ALEX. WINCHELL, of Syracuse, *Chairman.*
C. H. HITCHCOCK, of Hanover, *Secretary.*

B. NEW COMMITTEES.

1. *Committee to act with the Standing Committee in Nomination of Officers for the Meeting of* 1874.

SECTION A.

W. A. ROGERS, of Cambridge,
J. G. BARNARD, of New York,
G. W. HOUGH, of Albany,
H. F. WALLING, of Boston,

SECTION B.

A. C. HAMLIN, of Bangor,
S. H. SCUDDER, of Boston,
N. S. TOWNSHEND, of Columbus.
G. C. SWALLOW, of Columbia.

2. *Committee on the Elizabeth Thompson Donation.*

ASA GRAY, of Cambridge,
J. L. LECONTE, of Philadelphia,
P. H. VAN DER WEYDE, of N. Y.,
THOMAS HILL, of Portland,
JAMES HALL, of Albany,
T. STERRY HUNT, of Boston,
F. W. PUTNAM, of Salem.

3. *Committee to Report on the Principles of Nomenclature.*

J. L. LECONTE, of Philadelphia,
JAMES HALL, of Albany,
J. S. NEWBERRY, of Cleveland,
ALEXANDER AGASSIZ, Cambridge,
THEODORE GILL, of Washington.

4. *Committee to Report on the most desirable methods of Studying Science in the Common Schools.*

J. W. DAWSON, of Montreal,
S. W. JOHNSON, of New Haven,
J. P. LESLEY, of Philadelphia.

5. *Committee to Memorialize Congress and State Legislatures regarding the Cultivation of Timber, and the Preservation of Forests.*

F. B. HOUGH, of Lowville,
ASA GRAY, of Cambridge,
G. B. EMERSON, of Boston,
J. D. WHITNEY, of San Francisco,
J. S. NEWBERRY, of Cleveland,
L. H. MORGAN, of Rochester,
CHAS. WHITTLESEY, of Cleveland,
W. H. BREWER, of New Haven,
E. W. HILGARD, of Ann Arbor.

6. *Committee to Report on the Constitution of the Association.*

J. L. LECONTE, of Philadelphia,
C. S. LYMAN, of New Haven,
J. E. HILGARD, of Washington,
G. C. SWALLOW, of Columbia,
JOSEPH LOVERING, of Cambridge,
F. W. PUTNAM, of Salem.

7. *Committee to obtain an Act of Incorporation of the Association.*

GEORGE S. BOUTWELL,
F. A. P. BARNARD, of New York,
JOSEPH LOVERING, of Cambridge,
ASA GRAY, of Cambridge,
J. S. NEWBERRY, of Cleveland,
F. W. PUTNAM, of Salem,
W. W. WHEILDON, of Concord.

8. *Committee to Audit the Accounts of the Permanent Secretary and Treasurer.*

H. L. EUSTIS, of Cambridge,
HENRY WHEATLAND, of Salem.

OFFICERS OF THE ASSOCIATION

AND

LOCAL COMMITTEE ELECTED

FOR

THE HARTFORD MEETING.

PRESIDENT.

John L. LeConte, of Philadelphia.

VICE-PRESIDENT.

C. S. Lyman, of New Haven.

PERMANENT SECRETARY.

F. W. Putnam, of Salem.

GENERAL SECRETARY.

A. C. Hamlin, of Bangor.

TREASURER.

W. S. Vaux, of Philadelphia.

STANDING COMMITTEE.

EX-OFFICIO.

J. L. LeConte,
C. S. Lyman,
F. W. Putnam,
A. C. Hamlin,
W. S. Vaux,
Joseph Lovering,
A. H. Worthen,
C. A. White.

LOCAL COMMITTEE.

Hon. H. C. ROBINSON, *Chairman.*
Prof. JOHN BROCKLESBY, } *Vice-chairmen.*
J. M. ALLEN. }
Rev. W. L. GAGE, *Secretary.*
GEO. P. BISSELL, *Treasurer.*

TIMOTHY M. ALLYN,
JARED A. AYRES,
HENRY BARNARD,
F. F. BARROWS,
GEO. M. BARTHOLOMEW,
J. G. BATTERSON,
CHARLES M. BEACH,
H. B. BEACH,
E. B. BENNETT,
CHAS. E. BILLINGS,
B. F. BLAKESLEE,
JOHN W. BLISS,
LEVERETT BRAINARD,
CHARLES H. BRAINARD,
GEORGE BRIMLEY,
J. H. BROCKLESBY,
ISAAC H. BROMLEY,
CHARLES H. BUNCE,
JONATHAN B. BUNCE,
ALFRED E. BURR,
Rev. DR. HORACE BUSHNELL,
Hon. ELISHA CARPENTER,
FRANK W. CHENEY,
SAMUEL L. CLEMENS,
CHARLES J. COLE,
Rev. DR. C. B. CRANE,
Hon. CALVIN DAY,
AUSTIN DUNHAM,
AUSTIN C. DUNHAM,
Hon. W. W. EATON,
Dr. W. EDGECOMB,
THEODORE G. ELLIS,
RICHARD S. ELY,
Rev. MR. EMERSON,
GEO. A. FAIRFIELD,
Gen. W. B. FRANKLIN,
R. J. GATLING,
Hon. FRANCIS GILLETTE,
F. L. GLEASON,
W. H. GOODRICH,
Rev. FRANCIS GOODWIN,
JAMES GOODWIN,
JACOB L. GREENE,
EZRA HALL,
JOSEPH HALL,
WM. J. HAMERSLEY,
Rev. Prof. SAMUEL HART,
WM. A. HEALY,
CHARLES J. HOODLY,
Prof. GEO. O. HOLBROOKE
J. L. HOWARD,
Hon. R. D. HUBBARD,
W. M. HUDSON, M. D.,
E. K. HUNT, M. D.,
Rev. President A. JACKSON,
R. W. H. JARVIS,
PLINY JEWELL,
Hon. MARSHALL JEWELL,
HENRY KENEY,
Rev. C. F. KNIGHT,
JAMES LAURIE,
HORACE LORD,
Rt. Rev. F. P. McFARLAND,
THOMAS McMANUS,
L. W. MEECH,
Rev. Dr. M. MEIER-SMITH,
EDWARD J. MURPHY,
C. H. NORTHAM,
SAMUEL NOTT,
Hon. D. W. PARDEE,
Rev. E. P. PARKER,
JOHN C. PARSONS,
J. B. PIERCE,
ALBERT P. PITKIN,
Hon. C. M. POND,
Rev. Prof. T. R. PYNCHON,
CHARLES E. RICHARDS,
Rev. Prof. M. B. RIDDLE,
FREDERICK W. RUSSELL,
G. W. RUSSELL, M. D.,
Hon. NATHANIEL SHIPMAN,
Hon. GEORGE G. SILL,
W. E. SIMONDS,
Rev. C. A. SKINNER,
H. T. SPERRY,
J. H. SPRAGUE,
J. W. STANCLIFF,
HENRY P. STEARNS, M. D.
R. S. STORRS,
Rev. Prof. C. E. STOWE,
Hon. G. G. SUMNER,
Hon. J. H. TRUMBULL,
Rev. W. W. TURNER,
EDWIN S. TYLER,
J. C. WALKLEY,
CHARLES D. WARNER,
HENRY WILSON,
J. G. WOODWARD,

And the following from Middletown,

Rev. Prof. F. GARDINER, Rev. Prof. W. N. RICE, Prof. J. M. VAN VLECK.

MEETINGS OF THE AMERICAN ASSOCIATION FOR THE ADVANCEMENT OF SCIENCE.

MEETING.	DATE.	PLACE.	PRESIDENT.	VICE-PRESIDENT.	GENERAL SECRETARY.	PERMANENT SEC'Y.	TREASURER.
1st	Sept. 20, 1848,	Philadelphia, Pa.,	W. C. Redfield,*		Walter R. Johnson,*		Jeffries Wyman.
2d	Aug. 14, 1849,	Cambridge, Mass.,	Joseph Henry,		E. N. Horsford,		A. L. Elwyn.
3d	Mar. 12, 1850,	Charleston, S. C.,	A. D. Bache,*†		L. R. Gibbes,†		St. J. Ravenel.†
4th	Aug. 19, 1850,	New Haven, Conn.,	A. D. Bache,*		E. C. Herrick,		A. L. Elwyn.
5th	May 5, 1851,	Cincinnati, Ohio,	A. D. Bache,*		W. B. Rogers,	S. F. Baird,	A. L. Elwyn.
6th	Aug. 19, 1851,	Albany, N. Y.,	Louis Agassiz,*		W. B. Rogers,	S. F. Baird,	A. L. Elwyn.
7th	July 28, 1853,	Cleveland, Ohio,	Benjamin Peirce,		J. D. Dana,	S. F. Baird,	A. L. Elwyn.
8th	April 26, 1854,	Washington, D. C.,	J. D. Dana,		J. Lawrence Smith,	Joseph Lovering,	J. L. LeConte.†
9th	Aug. 15, 1855,	Providence, R. I.,	John Torrey,*		Wolcott Gibbs,	Joseph Lovering,	A. L. Elwyn.
10th	Aug. 20, 1856,	Albany, N. Y.,	James Hall,		B. A. Gould,	Joseph Lovering,	A. L. Elwyn.
11th	Aug. 12, 1857,	Montreal, Canada,	J. W. Bailey,*	Alexis Caswell,	John LeConte,	Joseph Lovering,	A. L. Elwyn.
12th	April 28, 1858,	Baltimore, Md.,	Alexis Caswell,†	John E. Holbrook,*	W. M. Gillespie,*	Joseph Lovering,	A. L. Elwyn.
13th	Aug. 3, 1859,	Springfield, Mass.,	Stephen Alexander,	Edward Hitchcock,*	William Chauvenet,*	Joseph Lovering,	A. L. Elwyn.
14th	Aug. 1, 1860,	Newport, R. I.,	Isaac Lea,	B. A. Gould,	Joseph LeConte,	Joseph Lovering,	A. L. Elwyn.
15th	Aug. 15, 1866,	Buffalo, N. Y.,	F. A. P. Barnard,	B. A. Gould,	Elias Loomis,	Joseph Lovering,	A. L. Elwyn.
16th	Aug. 21, 1867,	Burlington, Vt.,	J. S. Newberry,	Wolcott Gibbs,	C. S. Lyman,	Joseph Lovering,	A. L. Elwyn.
17th	Aug. 5, 1868,	Chicago, Ill.,	B. A. Gould,	Charles Whittlesey,	Simon Newcomb,†	Joseph Lovering,	A. L. Elwyn.
18th	Aug. 18, 1869,	Salem, Mass.,	J. W. Foster,*	O. N. Rood,	O. C. Marsh,	F. W. Putnam,†	A. L. Elwyn.
19th	Aug. 17, 1870,	Troy, N. Y.,	T. S. Hunt,†	T. S. Hunt,	F. W. Putnam,†	Joseph Lovering,	A. L. Elwyn.
20th	Aug. 16, 1871,	Indianapolis, Ind.,	Asa Gray,	G. F. Barker,	F. W. Putnam,	Joseph Lovering,	W. S. Vaux.
21st	Aug. 15, 1872,	Dubuque, Iowa,	J. Lawrence Smith,	Alex. Winchell,	E. S. Morse,	Joseph Lovering,	W. S. Vaux.
22d	Aug. 20, 1873,	Portland, Me.,	Joseph Lovering,	A. H. Worthen,‡	C. A. White,	F. W. Putnam,	W. S. Vaux.

* Deceased. † In the absence of the regular officer. ‡ Not present at the meeting.

CONSTITUTION OF THE ASSOCIATION.*

OBJECTS.

THE Association shall be called THE AMERICAN ASSOCIATION FOR THE ADVANCEMENT OF SCIENCE.

The objects of the Association are, by periodical and migratory meetings, to promote intercourse between those who are cultivating science in different parts of the United States; to give a stronger and more general impulse and a more systematic direction to scientific research in our country; and to procure for the labors of scientific men increased facilities and a wider usefulness.

MEMBERS.

RULE 1. Any person may become a member of the Association upon recommendation in writing by two members, nomination by the Standing Committee, and election by a majority of the members present.

OFFICERS.

RULE 2. The officers of the Association shall be a President, Vice President, General Secretary, Permanent Secretary, and Treasurer. The President, Vice-President, General Secretary, and Treasurer shall be elected at each meeting for the following one; — the three first named officers not to be reëligible for the next two meetings, and the Treasurer to be reëligible as long as the Association may desire. The Permanent Secretary shall be elected at each second meeting, and also be reëligible as long as the Association may desire.

* Adopted August 25, 1856, and ordered to go into effect at the opening of the Montreal Meeting. Amended at Burlington, August, 1867, and at Chicago, August, 1868.

MEETINGS.

RULE 3. The Association shall meet, at such intervals as it may determine, for one week, or longer; and the arrangements for it shall be intrusted to the officers and the Local Committee. The Standing Committee shall have power to determine the time and place of each meeting, and shall give due notice of it to the Association.

STANDING COMMITTEE.

RULE 4. There shall be a Standing Committee, to consist of the President, Vice President, Secretaries, and Treasurer of the Association, the officers of the preceding year, the Permanent Chairmen of the Sectional Committees, after these shall have been organized, and six members present from the Association at large, who shall have attended any of the previous meetings, to be elected upon open nomination by ballot on the first assembling of the Association. A majority of the whole number of votes cast, to elect. The General Secretary shall be Secretary of the Standing Committee.

The duties of the Standing Committee shall be,—

1. To assign papers to the respective Sections.

2. To arrange the scientific business of the general meetings, to suggest topics, and arrange the programmes for the evening meetings.

3. To suggest to the Association the place and time of the next meeting.

4. To examine, and, if necessary, to exclude papers.

5. To suggest to the Association subjects for scientific reports and researches.

6. To appoint the Local Committee.

7. To have the general direction of publications.

8. To manage any other general business of the Association during the session, and during the interval between it and the next meeting.

9. In conjunction with four from each Section, to be elected by the Sections for the purpose, to make nominations of officers of the Association for the following meeting.

10. To nominate persons for admission to membership.

11. Before adjourning, to decide which papers, discussions, or other proceedings shall be published.

SECTIONS.

RULE 5. The Association shall be divided into two Sections, and as many sub-sections as may be necessary for the scientific business. When not otherwise ordered the sub-sections shall be as follows: SECTION A.—(1) Mathematics and Astronomy; (2) Physics and Chemistry; (3) Microscopy. SECTION B.—(1) Zoölogy and Botany; (2) Geology and Palæontology; (3) Ethnology and Archæology. The two sections may meet as one.

SECTIONAL OFFICERS AND COMMITTEES.

RULE 6. On the first assembling of the Section, the members shall elect upon open nomination a permanent Chairman and Secretary, also three other members, to constitute, with these officers, a Sectional Committee.

The Section shall appoint, from day to day, a Chairman to preside over its meetings.

RULE 7. It shall be the duty of the Sectional Committee of each Section to arrange and direct the proceedings in their Section; to ascertain what communications are offered; to assign the order in which these communications shall appear, and the amount of time which each shall occupy.

The Sectional Committees may likewise recommend subjects for systematic investigation by members willing to undertake the researches, and to present their results at the next meeting.

The Sectional Committee may likewise recommend reports on particular topics and departments of science, to be drawn up as occasion permits, by competent persons, and presented at subsequent meetings.

REPORTS OF PROCEEDINGS.

RULE 8. Whenever practicable, the proceedings shall be reported by professional reporters, or stenographers, whose reports are to be revised by the Secretaries before they appear in print.

PAPERS AND COMMUNICATIONS.

RULE 9. No paper shall be placed in the programme, unless admitted by the Sectional Committee; nor shall any be read, unless an abstract of it has been previously presented to the Secretary of the Section, who shall furnish to the Chairman the titles of papers, of which abstracts have been received.

RULE 10. The author of any paper or communication shall be at liberty to retain his right of property therein, provided he declare such to be his wish before presenting it to the Association.

RULE 11. Copies of all communications, made either to the General Association or to the Sections, must be furnished by the authors; otherwise, only the titles, or abstracts, shall appear in the published proceedings.

RULE 12. All papers, either at the general or in the sectional meetings, shall be read, as far as practicable, in the order in which they are entered upon the books of the Association; except that those which may be entered by a member of the Standing Committee of the Association shall be liable to postponement by the proper Sectional Committee.

RULE 13. If any communication be not ready at the assigned time, it shall be dropped to the bottom of the list, and shall not be entitled to take precedence of any subsequent communication.

RULE 14. No exchanges shall be made between members without authority of the respective Sectional Committees.

GENERAL AND EVENING MEETINGS.

RULE 15. The Standing Committee shall appoint any general meeting which the objects and interests of the Association may call for, and the evenings shall, as a rule, be reserved for general meetings of the Association.

These general meetings may, when convened for that purpose, give their attention to any topics of science which would otherwise come before Sections.

It shall be a part of the business of these general meetings to receive the Address of the President of the last meeting; to hear such reports on scientific subjects as, from their general importance and interest, the Standing Committee shall select; also to receive from the Chairmen of the Sections abstracts of the proceedings of their respective Sections; and to listen to communications and lectures explanatory of new and important discoveries and researches in science, and new inventions and processes in the arts.

ORDER OF PROCEEDINGS IN ORGANIZING A MEETING.

RULE 16. The Association shall be called to order by the President of the preceding meeting; and this officer having resigned the chair to the President elect, the General Secretary shall then report the number of papers relating to each department which have been registered, and the Association consider the most eligible distribution into Sections, when it shall proceed to the election of the additional members of the Standing Committee in the manner before described; the meeting shall then adjourn, and the Standing Committee, having divided the Association into Sections as directed, shall allot to each its place of meeting for the Session. The Sections shall then organize by electing their officers and their representatives in the Nominating Committee, and shall proceed to business.

PERMANENT SECRETARY.

RULE 17. It shall be the duty of the Permanent Secretary to notify members who are in arrears, to provide the necessary stationery and suitable books for the list of members and titles of papers, minutes of the general and sectional meetings, and for other purposes indicated in the rules, and to execute such other duties as may be directed by the Standing Committee or by the Association.

The Permanent Secretary shall make a report, annually, to the Standing Committee, at its first meeting, to be laid before the Association, of the business of which he has had charge since its last meeting.

All members are particularly desired to forward to the Permanent Secretary, so as to be received before the day appointed for the Association to convene, complete titles of all the papers which they expect to present during its meeting, with an estimate of the time required for reading each, and such abstracts of their contents as may give a general idea of their nature.

Whenever the Permanent Secretary notices any error of fact or unnecessary repetition, or any other important defect in the papers communicated for publication in the "Proceedings" of the Association, he is authorized to commit the same to the author, or to the proper sub-committee of the Standing Committee for correction.

LOCAL COMMITTEE.

RULE 18. The Local Committee shall be appointed from among members residing at, or near, the place of meeting for the ensuing year; and it shall be the duty of the Local Committee, assisted by the officers, to make arrangements and the necessary announcements for the meeting.

The Secretary of the Local Committee shall issue a circular in regard to the time and place of meetings, and other particulars, at least one month before each meeting.

SUBSCRIPTIONS.

RULE 19. The amount of the subscription, at each meeting, of each member of the Association, shall be two dollars, and one dollar in addition shall entitle him to a copy of the "Proceedings" of the annual meeting. These subscriptions shall be received by the Permanent Secretary, who shall pay them over, after the meeting, to the Treasurer.

The admission fee of new members shall be five dollars, in addition to the annual subscription; and no person shall be considered a member of the Association until this admission fee and the subscription for the meeting at which he is elected have been paid.

RULE 20. The names of all persons two years in arrears for annual dues shall be erased from the list of members; provided that two notices of indebtedness, at an interval of at least three months, shall have been previously given.

ACCOUNTS.

RULE 21. The accounts of the Association shall be audited, annually, by auditors appointed at each meeting.

ALTERATIONS OF THE CONSTITUTION.

RULE 22. No article of this Constitution shall be altered, or amended, or set aside, without the concurrence of three-fourths of the members present, and unless notice of the proposed change shall have been given at the preceding annual meeting.

RESOLUTIONS

OF A PERMANENT AND PROSPECTIVE CHARACTER, ADOPTED AUGUST 19, 1857.

---

1. No appointment may be made in behalf of the Association, and no invitation given or accepted, except by vote of the Association or its Standing Committee.

2. The General Secretary shall transmit to the Permanent Secretary for the files, within two weeks after the adjournment of every meeting, a record of the proceedings of the Association and the votes of the Standing Committee. He shall also, daily, during the meetings, provide the Chairman of the two Sectional Committees with lists of the papers assigned to their Sections by the Standing Committee.

3. All printing for the Association shall be superintended by the Permanent Secretary, who is authorized to employ a clerk for that especial purpose.

4. The Permanent Secretary is authorized to put the "Proceedings" of the meeting to press one month after the adjournment of the Association. Papers which have not been received at that time may be published only by title. No notice of articles not approved shall be taken in the published "Proceedings."

5. The Permanent Chairmen of the Sections are to be considered their organs of communication with the Standing committee.

6. It shall be the duty of the Secretaries of the two Sections to receive copies of the papers read in their Sections, all sub-sections included, and to furnish them to the Permanent Secretary at the close of the meeting.

7. The Sectional Committees shall meet not later than nine, A.M., daily, during the meetings of the Association, to arrange the programmes of their respective Sections, including all sub-sections,

for the following day. No paper shall be placed upon these programmes which shall not have been assigned to the Section by the Standing Committee. The programmes are to be furnished to the Permanent Secretary not later than eleven, A.M.

8. During the meetings of the Association, the Standing Committee shall meet daily, Sunday excepted, at nine, A.M., and the Sections be called to order at ten, A.M., unless otherwise ordered. The Standing Committee shall also meet on the evening preceding the first assembling of the Association at each annual meeting, to arrange for the business of the first day; and on this occasion three shall form a quorum.

9. Associate members may be admitted for one, two, or three years, as they shall choose at the time of admission,—to be elected in the same way as permanent members, and to pay the same dues. They shall have all the social and scientific privileges of members, without taking part in the business.

10. No member may take part in the organization and business arrangement of both the Sections.

MEMBERS

OF THE

AMERICAN ASSOCIATION

FOR THE

ADVANCEMENT OF SCIENCE.*

A.

Abbe, Prof. Cleveland, Cincinnati, Ohio (16).
Abbot, Miss Elizabeth O., No. 10 Thomas St., Providence, R. I. (20).
Adams, Samuel, Jacksonville, Ill. (18).
Adcock, Prof. Robert J., Monmouth, Warren Co., Ill. (21).
Addams, Miss S. Alice, Cedarville, Ill. (21).
Agassiz, Alexander, Curator Mus. Comp. Zoology, Cambridge, Mass. (18).
Aiken, Prof. W. E. A., Baltimore, Md. (12).
Ainsworth, Frank B., Supt. Ind. House of Refuge, Plainfield, Ind. (20).
Albert, Augustus J., Baltimore, Md. (12).
Alexander, John S., 1935 Arch St., Philadelphia, Penn. (20).
Alexander, Prof. Stephen, Princeton, N. J. (1).
Allen, Joel A., Mus. Comp. Zool., Cambridge, Mass. (18).
Allen, J. M., Hartford, Conn. (22).
Allen, Zachariah, Providence, R. I. (1).
Allyn, Mrs. Clarence, Nyack on the Hudson, N. Y. (22).
Alvord, Benjamin, U.S.A., Paymaster Gen. Office, Washington, D. C. (17).
Andrews, Prof. E. B., Lancaster, Ohio (7).
Andrews, Dr. Edmund, Chicago, Ill. (22).
Appleton, Prof. John H., Brown University, Providence, R. I. (22).
Arthur, J. C., Charles City, Iowa (21).
Atkinson, Prof. Wm. K., 41 East Ninth St., New York (22).
Atwater, Samuel T., 166 Washington St., Chicago, Ill. (17).
Atwater, Mrs. Samuel T., 166 Washington St., Chicago, Ill. (17).
Austin, E. P., Box 434, North Cambridge, Mass. (18).
Avery, Alida C., Poughkeepsie, N. Y. (20).

* The numbers in parentheses indicate the meeting at which the member was elected. When no address is given, it signifies that the Hartford Circular has been returned through the mail as uncalled for, having been addressed by the list given in the preceding volume.

B.

Babcock, George, Sup't Rensselaer Iron Works, Troy, N. Y. (19).
Babcock, Henry H., Principal Chicago Acad. 11 18th St., Chicago, Ill. (17).
Bacon, Dr. John, jr., Boston, Mass. (1).
Bailey, Prof. Loring W., University of Frederickton, N. B. (18).
Baird, Lyman, 90 La Salle St., Chicago, Ill. (17).
Baird, Prof. S. F., Smithsonian Institution, Washington, D. C. (1).
Baker, Prof. T. R., Millersville, Penn. (22).
Balch, David M., Salem, Mass. (22).
Bannister, Henry M., Washington, D. C. (17).
Bardwell, Prof. F. W., University of Kansas, Lawrence, Kan. (13).
Barker, Prof. G. F., 408 South 41st St., Philadelphia, Pa. (13).
Barnard, F. A. P., President Columbia College, New York (7).
Barnard, Gen. J. G., U.S.A., Army Building, New York (14).
Barrett, Moses, Milwaukee, Wis. (21).
Bartlett, Frank L., Hanover, Me. (22).
Basnett, Thomas, Ottawa, Ill. (8).
Bass, George F., 336 North Noble St., Indianapolis, Ind. (21).
Bassett, George W., Vandalia, Ill. (20).
Batchelder, Dr. J. H., Salem, Mass. (18).
Batchelder, John M., No. 16 Pemberton Sq., Boston, Mass. (8).
Beach, Myron H., Dubuque, Iowa (21).
Beach, W. H., Dubuque, Iowa (21).
Bebb, Michael G., Fountaindale, Iowa (21).
Becker, Dr. Alexander R., Providence, R. I. (22).
Bell, James D., Office of Daily Graphic, New York (20).
Bell, John J., Exeter, N. H. (22).
Bell, Samuel N., Manchester, N. H. (7).
Benjamin, E. B., 10 Barclay St., New York (17).
Bessey, Prof. C. E., Agricultural College, Ames, Iowa (21).
Bethune, Rev. Charles J. S., Port Hope, Canada (18).
Bickmore, Prof. Albert S., Arsenal Building, 6 Central Park, N. Y. (17).
Bicknell, Edwin, Cambridge, Mass. (18).
Bill, Charles, Springfield, Mass. (17).
Blake, Eli W., New Haven, Conn. (1).
Blake, Prof. Eli W., jr., Providence, R. I. (15).
Blatchford, Eliphalet W., Chicago, Ill. (17).
Blodgett, James H., Rockford, Ill. (21).
Boadle, John, Haddonfield, N. J. (20).
Bolles, Rev. E. C., Salem, Mass. (17).
Bolton, Dr. H. C., 49 West 51st St., New York (17).
Bontecou, Dr. R. B., Troy, N. Y. (19).
Bouvé, Thomas T., Pres't Boston Soc. Nat. History, Boston, Mass. (1).
Bowditch, Dr. Henry I., 113 Boylston St., Boston, Mass. (2).
Bowen, Silas T., Indianapolis, Ind. (20).

Boynton, Miss Susan P., Box 150, Lynn, Mass. (19).
Brackett, Prof. C. F., College of New Jersey, Princeton, N. J. (19).
Bradley, L., 9 Exchange Place, Jersey City, N. J. (15).
Breneman, A. A., Agricultural College, Lancaster, Penn. (20).
Brevoort, J. Carson, Brooklyn, N. Y. (1).
Brewer, Prof. W. H., New Haven, Conn. (20).
Briggs, Albert D., Springfield, Mass. (13).
Briggs, S. A., Box 545, Chicago, Ill. (17).
Brigham, Charles H., Ann Arbor, Mich. (17).
Bross, William, Chicago, Ill. (7).
Brown, Robert, jr., Office Cincinnati Gas Light Co., Cincinnati, Ohio (11).
Brown, Mrs. Robert, jr., Cincinnati, Ohio (17).
Brush, Prof. George J., Yale College, New Haven, Conn. (11).
Bryan, Oliver N., Accokeek P. O., Prince George's Co., Md. (18).
Bryant, Wm. M., Sup't City Schools, Burlington, Iowa (21).
Buckhout, W. A. (20).
Burbank, L. S., Woburn, Mass. (18).
Burgess, Miss Abbie L., Western Female Sem., Oxford, Ohio (20).
Burgess, Edward, Sec'y Nat. Hist. Society, Boston, Mass. (22).
Burton, H. J., jr., Boston, Mass. (22).
Bush, Rev. Alva, Cedar Valley Sem., Osage, Iowa (21).
Bush, Stephen, Waterford, N. Y. (19).
Bushee, Prof. James, Worcester, Mass. (9).

C.

Campbell, Mrs. Mary, Crawfordsville, Ind. (22).
Carmichael, Prof. Henry, Bowdoin College, Brunswick, Me. (21).
Carpenter, Prof. G. C., Simpson Centenary College, Indianola, Iowa (22).
Carrier, Joseph C., Notre Dame, Ind. (20).
Carrington, Henry B., Crawfordsville, Ind. (20).
Case, Leonard, Cleveland, Ohio (15).
Caswell, Prof. Alexis, Providence, R. I. (2).
Cattell, William C., President Lafayette College, Easton, Penn. (15).
Chadbourne, Prof. P. A., Pres't Williams Coll., Williamstown, Mass. (10).
Chadeayne, Miss E., Jersey City, N. J. (22).
Chamberlain, T. C., Whitewater, Wis. (21).
Chandler, William H. (19).
Chanute, O., Chief Engineer Erie Railway Co., New York (17).
Chapman, F. M., 90 La Salle St., Chicago, Ill. (17).
Chase, Prof. Pliny E., Haverford College, Haverford, Penn. (18).
Chase, R. Stuart, 16 Merrimack St., Haverhill, Mass. (18).
Chesbrough, E. S., Chicago, Ill. (2).
Chickering, Prof. J. W., jr., Deaf Mute College, Washington, D. C. (22).
Clark, John E., 45 Clark St., New Haven, Conn. (17).
Clarke, Prof. F. W., Howard University, Washington, D. C. (18).
Coffin, Prof. John H. C., U.S.N., Washington, D. C. (1).

Coffin, Prof. Selden J., Lafayette College, Easton, Penn. (22).
Coffinberry, W. L., Grand Rapids, Mich. (20).
Cogswell, Dr. George, Bradford, Mass. (18).
Colbert, E., Chicago, Ill. (17).
Collett, Hon. John, Newport, Ind. (17).
Collins, Prof. Alonzo, Cornell College, Mount Vernon, Iowa (21).
Colton, G. Woolworth, (22).
Comstock, Prof. M. L., Galesburg, Ill. (21).
Conser, Prof. E. P., Sand Spring, Iowa (21).
Cook, Prof. George H., Lock Box 5, New Brunswick, N. J. (18).
Cooke, Caleb, Peabody Academy of Science, Salem, Mass. (18).
Cooley, Prof. Le Roy C., N. Y. State Normal School, Albany, N. Y. (19).
Cope, Prof. Edward D., Haddonfield, N. J. (17).
Copes, Dr. Joseph S., care Copes & Ogden, New Orleans, La. (11).
Cornwall, Prof. Henry B., College of New Jersey, Princeton, N. J. (22).
Cox, Prof. Edward T., Indianapolis, Ind. (19).
Cramp, Dr. J. M., Wolfville, N. S. (11).
Crawford, Dr. John S., Galena, Ill. (21).
Crocker, Charles F., Lawrence, Mass. (22).
Crocker, Mrs. Charles F., Lawrence, Mass. (21).
Cummings, John, Woburn, Mass. (18).
Cummings, Rev. Dr. Joseph, Pres't Wesleyan Univ., Middletown, Ct. (18).
Curtis, Dr. Josiah, Ebbitt House, Washington, D. C. (18).
Curtis, Rev. Dr. W. S., Rockford, Ill. (21).
Cutting, Dr. Hiram A., Lunenburgh, Vt. (17).

D.

Dall, Mrs. Caroline H., 141 Warren Ave., Boston, Mass. (18).
Dall, William H., Box 1869, San Francisco, Cal. (18).
Dalrymple, Rev. Dr. E. A., Baltimore, Md. (1).
Dana, Prof. James D., New Haven, Conn. (1).
Danforth, Edward, Department of Public Instruction, Albany, N. Y. (11).
Darby, Prof. John, Wesleyan University, Millersburg, Ky. (21).
Davenport, Mrs. M. G., Oskaloosa, Iowa (21).
Davis, James, 117 State, corner of Broad St., Boston, Mass. (1).
Dawson, Dr. J. W., Principal McGill College, Montreal, Can. (10).
Day, Dr. F. H., Wauwatosa, Wis. (20).
Dean, George W., Fall River, Mass. (15).
DeCamp, Dr. William H., Grand Rapids, Mich. (21).
Delano, Joseph C., New Bedford, Mass. (5).
DeLaski, Dr. John, Carver's Harbor, Me. (18).
Devereux, J. H., Mich. Southern Railway, Cleveland, Ohio (18).
Dimmock, George, Springfield, Mass. (22).
Dinwiddie, Robert, 118 Water St., New York (1).
Dixwell, Epes S., Cambridge, Mass. (1).
Dodd, C. M., Williamstown, Mass. (19).

Dodge, Charles R., Washington, D. C. (22).
Doggett, Wm. E., Chicago, Ill. (17).
Doggett, Mrs. Wm. E., Chicago, Ill. (17).
Dolbear, A. Emerson, Bethany, West Va. (20).
Doughty, John W., Newburgh, N. Y. (19).
Downer, Henry E., Detroit, Mich. (21).
Drowne, Charles, Rensselaer Polytechnic Institute, Troy, N. Y. (6).
Drummond, Josiah H., Portland, Me. (22).
Duncan, Dr. T. C., 287 West Randolph St., Chicago, Ill. (17).
Dyer, Clarence, Lawrence, Mass. (22).
Dyer, Elisha, 87 Westminster St., Providence, R. I. (9).

E.

Eaton, Prof. D. G., Packer Institute, Brooklyn, N. Y. (19).
Eaton, Prof. James H., Beloit College, Beloit, Wis. (17).
Edgar, George M., Pres't Franklin Female College, Franklin, Ky. (20).
Edwards, Dr. A. M., 241 Broad St., Newark, N. J. (18).
Edwards, Thomas C., Vineland, N. J. (21).
Eimbeck, Wm., P. O. Box 1600, San Francisco, Cal. (17).
Elliott, Ezekiel B., Statistical Bureau, Washington, D. C. (10).
Elwyn, Alfred L., Philadelphia, Penn. (1).
Emerson, Prof. Benjamin K., Amherst, Mass. (19).
Emerson, Prof. Charles F., Dartmouth College, Hanover, N. H. (22).
Emerson, George B., LL.D., 3 Pemberton Sq., Boston, Mass. (1).
Emerton, James H., Salem, Mass. (18).
Endlech, Frederic N., Smithsonian Institution, Washington, D. C. (22).
Engelmann, Dr. George, St. Louis, Mo. (1).
Engstrom, A. B., Burlington, N. J. (1).
Ennis, Jacob, Principal Scientific Inst., Philadelphia, Penn. (19).
Eustis, Prof. Henry L., Cambridge, Mass. (2).
Evans, Asher B., Principal Union School, Lockport, N. Y. (19).
Everett, Dr. Oliver, Dixon, Ill. (21).
Everts, Miss M. M. (22).

F.

Fairbanks, Henry, St. Johnsbury, Vt. (14).
Faries, R. J., Wauwatosa, Wis. (21).
Farmer, Moses G., Salem. Mass. (9).
Farnham, Thomas, Buffalo, N. Y. (15).
Fellowes, R. S., New Haven, Conn. (18).
Fenton, William, Milwaukee, Wis. (18).
Fernald, Prof. Charles H., State Agricultural College, Orono, Me. (22).
Fernald, Prof. M. C., State Agricultural College, Orono, Me. (22).
Ferrell, William, Cambridge, Mass. (11).
Feuchtwanger, Dr. Lewis, 180 Fulton St., New York (11).
Ficklin, Prof. Joseph, University of Missouri, Columbia, Mo. (20).
Fishback, W. P., St. Louis, Mo. (20).

Fisher, Prof. Davenport, from June 1 to Oct. 1, 642 Marshall St., Milwaukee, Wis.; rest of the year, Annapolis, Md. (17).
Fisk, Rev. Dr. Richmond, jr., Grand Rapids, Mich. (19).
Fitch, Edward H., Ashtabula, Ohio (11).
Fitch, O. H., Ashtabula, Ohio (7).
Fletcher, Ingram, care Fletcher & Sharpe, Indianapolis, Ind. (20).
Fletcher, Dr. Wm. B., Indianapolis, Ind. (20).
Fluegel, Maurice (21).
Foote, Dr. A. E., Agricultural College, Ames, Iowa (21).
Ford, Silas W., 24 7th St., Troy, N. Y. (19).
Forshey, Col. C. G., New Orleans, La. (21).
Foster, Henry, Clifton, N. Y. (17).
Freeman, H. C., La Salle, Ill. (17).
French, Dr. Geo. F., Portland, Me. (22).
Frothingham, Rev. Frederick, Buffalo, N. Y. (11).
Fuller, Charles B., Portland, Me. (22).
Fulton, Prof. Robert B., University of Miss., Oxford, Miss. (21).

G.

Garbett, Wm. A., 22 Guild Row, Boston Highlands, Mass. (22).
Garmann, S. W., Mus. Comp. Zool., Cambridge, Mass. (20).
Garrett, Ellwood, Wilmington, Newcastle County, Del. (22).
Gaskill, Joshua, Lockport, N. Y. (22).
Gavit, John E., 142 Broadway, N. Y. (1).
Gill, Prof. Theodore, Smithsonian Institution, Washington, D. C. (17).
Gilman, Prof. Daniel C., Pres't University of California, Oakland, Cal. (10).
Glazier, Sarah M., Chelsea, Mass. (19).
Goessman, Prof. C. A., State Agricultural College, Amherst, Mass. (18).
Gold, Theodore S., West Cornwall, Conn. (4).
Goodale, Prof. G. L., Botanic Gardens, Cambridge, Mass. ( ).
Goode, Prof. George Brown, Middletown, Conn. (22).
Goodell, Abner C., jr., Salem, Mass. (18).
Goold, W. N., Sec'y Portland Society Natural History, Portland, Me. (22).
Gould, Prof. B. A., Cambridge, Mass. (2).
Gould, Sylvester C., Manchester, N. H. (22).
Graves, G. A., Ackley, Iowa (21).
Gray, Prof. Asa, Botanical Gardens, Cambridge, Mass. (1).
Green, Dr. Samuel E., Blairsville, Penn. (22).
Green, Dr. Traill, Easton, Penn. (1).
Greene, Dascom, Troy, N. Y. (17).
Greene, David M., Troy, N. Y. (19).
Greene, Francis C., Easthampton, Mass. (11).
Greer, James, Dayton, Ohio (20).
Gregory, Prof. J. J. H., Marblehead, Mass. (18).
Griffith, Miss E. A., Mt. Pleasant, Iowa (21).
Grimes, J. Stanley, Evanston, Ill. (17).
Grinnan, A. G., Orange Court House, Va. (7).
Grote, Aug. R., Sec'y Buffalo Soc. Nat. History, Buffalo, N. Y. (22).

Gunning, William D., Waltham, Mass. (22).
Guyot, Prof. Arnold, Princeton, N. J. (1).

H.

Hadley, George, Buffalo, N. Y. (6).
Hagen, Dr. Hermann A., Mus. Comp. Zool., Cambridge, Mass. (17).
Haldeman, Prof. S. S., Columbia, Penn. (1).
Hale, Dr. William H., Albany, N. Y. (19).
Hall, Benjamin H., Troy, N. Y. (19).
Hall, George E., Cleveland, Ohio (19).
Hall, Prof. James, Albany, N. Y. (1).
Hall, L. B., Windsor, Vt. (18).
Hall, Hon. Nathan K. (7).
Hambly, J. B., Portsmouth, R. I. (18).
Hamel, Thomas E., Quebec, Canada (18).
Hamlin, Dr. A. C., Bangor, Me. (10).
Hanaman, C. E., Troy, N. Y. (19).
Hance, Ebenezer, Fallsington P. O., Bucks County, Penn. (7).
Harrington, Prof. Mark W., Ann Arbor, Mich. (22).
Harrison, Dr. B. F. Wallingford, Conn. (11).
Hart, Rev. Samuel, Hartford, Conn. (22).
Hartshorne, Prof. Henry, Haverford College, Montgomery Co., Penn. (12).
Harvey, Charles W., Sup't Public Schools, Greensburg, Ind. (20).
Harvey, Dr. Leon F., Buffalo, N. Y. (22).
Harwood, Miss Grace, Council Hill, Ill. (21).
Hawkins, Dr. B. W., 9 Beacon St., Boston, Mass. (17).
Hayes, George E., Buffalo, N. Y. (15).
Hedrick, B. S., Washington, D. C. (19).
Henderson, George L., LeRoy, Minn. (21).
Henry, Prof. Joseph, Sec'y Smithsonian Institution, Washington, D.C. (1).
Hervey, Rev. A. B., 10 North 2d St., Troy, N. Y. (22).
Hilgard, Prof. Eugene W., Ann Arbor, Mich. (1).
Hilgard, Prof. Julius E., U. S. Coast Survey, Washington, D. C. (4).
Hilgard, Dr. Theodore C., care Dr. Tyndale, 121 Rivington St., N. Y. (17).
Hill, S. W., Hancock, Lake Superior (6).
Hill, Rev. Dr. Thomas, 53 State St., Portland, Me. (3).
Hinrichs, Prof. Gustavus, State University, Iowa City, Iowa (17).
Hitchcock, Prof. Charles H., Hanover, N. H. (1).
Hoadley, E. S., Springfield, Mass. (18).
Holley, Miss E. P., Niagara Falls, N. Y. (20).
Holley, George W., Niagara Falls, N. Y. (19).
Holmes, Thomas, Merom, Ind. (20).
Homes, Henry A., Librarian State Library, Albany, N. Y. (11).
Horr, Dr. Asa, Dubuque, Iowa (21).
Horribin, William T., Cohoes, N. Y. (19).
Horsford, Prof. E. N., Cambridge, Mass. (1).
Hosford, Charles E., Terre Haute, Ind. (20).

Hough, Franklin B., Lowville, N. Y. (4).
Hough, G. W., Albany, N. Y. (15).
Houk, Mrs. George W., Dayton, Ohio (22).
House, John C., Union Gas Works, Waterford, N. Y. (19).
Hovey, Prof. Edmund O., Wabash College, Crawfordsville, Ind. (20).
Hovey, Mrs. Edmund O., Crawfordsville, Ind. (21).
Hovey, Miss Mary F., Crawfordsville, Ind. (20).
Howe, E. C., Yonkers, N. Y. (19).
Hoy, Dr. Philo R., Racine, Wis. (17).
Hubbard, Prof. Oliver P., New Haven, Conn. (1).
Hubbard, Mrs. Sara A., No. 31 Thirty-third St., Chicago, Ill. (17).
Humphrey, D., Lawrence, Mass. (18).
Humphreys, A. W., Box 1384, N. Y. (20).
Hunt, George, Providence, R. I. (9).
Hunt, Miss Sarah E., Salem, Mass. (20).
Hunt, Dr. T. Sterry, St. James Hotel, Boston, Mass. (1).
Huntington, Prof. J. H., Hanover, N. H. (19).
Hyatt, Prof. Alpheus, Natural History Society, Boston, Mass. (18).
Hyatt, James, Stanfordville, Dutchess Co., N. Y. (10).
Hyatt, Jonathan S., Morrisiana, N. Y. (19).

I.

Irish, Thomas M., Box 2127, Dubuque, Iowa (21).

J.

Jackson, Prof. C. L., care P. T. Jackson, Boston, Mass. (20).
Jackson, Lewis McL., Middletown, Conn. (22).
James, Thomas Potts, Cambridge, Mass. (22).
Jasper, Gustavus A., 12 Central St., Boston, Mass. (18).
Jenks, Elisha T., Middleboro, Mass. (22).
Jenks, Prof. J. W. P., Middleboro, Mass. (2).
Jillson, Dr. B. C., Pittsburgh, Penn. (14).
Johnson, Prof. Hosmer A., Academy of Sciences, Chicago, Ill. (22).
Johnson, Prof. S. W., Yale College, New Haven, Conn. (22).
Johnston, Prof. John, Middletown, Conn. (1).
Jones, William P., Ravenswood, Ill. (21).
Joy, Prof. C. A., Columbia College, New York (8).
Joyce, Rev. J. J., jr., 33 North 17th St., Philadelphia, Penn. (22).

K.

Keely, Prof. G. W., Waterville, Me. (1).
Kellogg, Justin, 259 River St., Troy, N. Y. (19).
Kennedy, Mrs. Mary R., St. Louis, Gratiot Co., Mich. (19).
Kerr, Prof. W. C., Raleigh, N. C. (10).
Kimball, Dr. Frank B., Reading, Mass. (22).
Kimball, Dr. J. P., New York (15).
Kinder, Miss Sarah, 27 Lockerbie St., Indianapolis, Ind. (20).

King, Miss Mary B. A., Rochester, N. Y. (15).
King, Robert, Kalamazoo, Mich. (21).
King, V. O., New Orleans, La. (21).
King, William F., President Cornell College, Mt. Vernon, Iowa (21).
Kinner, Dr. Hugo, 1517 South Seventh St., St. Louis, Mo. (21).
Kirkpatrick, James A., 19 South Fifth St. Philadelphia, Penn. (7).
Kirkwood, Daniel, Bloomington, Ind. (7).
Klippart, John H., Cor. Sec'y State Board of Agriculture, Box 1453, Columbus, Ohio (17).
Knapp, Frederick N., Plymouth, Mass. (19).
Knapp, Dr. Herman, 25 West Twenty-fourth St., N. Y. (22).
Kneeland, Dr. Samuel, Mass. Institute of Technology, Boston, Mass. (20).
Knepper, C. O., Waverly, Iowa (21).
Knight, J. B., No. 30 North Fifth St., Philadelphia, Penn. (21).
Knox, Otho S., Waterloo, Iowa (21).

L.

Lambert, Thomas R., Charlestown, Mass. (18).
Lambert, T. S., New York (21).
Langley, S. P., Director Observatory, Allegheny, Penn. (18).
Lapham, Dr. Increase A., Chief of Geological Corps, Milwaukee, Wis. (3).
Lattimore, Prof. S. A., University of Rochester, Rochester, N. Y. (15).
Lawrence, Hon. Edw., Pres't Bunker Hill N. Bk., Charlestown, Mass. (18).
Lawrence, George N., 172 Pearl St., New York (7).
Lea, Dr. Isaac, 1622 Locust St., Philadelphia, Penn. (1).
Leakin, Rev. George A., Baltimore, Md. (17).
Lebourveau, Alonzo, Watertown, Wis. (22).
Leckie, Robert G., Actonvale, Quebec, Canada (19).
LeConte, Dr. John L., 1625 Spruce St., Philadelphia, Penn. (1).
Lennon, W. H., Normal School, Brockport, N. Y. (19).
Leonard, N. R., State University, Iowa City, Iowa (21).
Lesley, Joseph, jr., 233 South Fourth St., Philadelphia, Penn. (8).
Lesley, Prof. J. P., Philadelphia, Pa. (2).
Lindsley, Dr. J. B., Nashville, Tenn. (1).
Lintner, J. A., Albany, N. Y. (22).
Little, Prof. George, Oxford, Miss. (15).
Little, W. C., Albany, N. Y. (22).
Locke, Erie (20).
Lockwood, Rev. Samuel, Freehold, N. J. (18).
Logan, Sir William E., 15 St. Lambert St., Montreal, Canada (1).
Loomis, Prof. Elias, New Haven, Conn. (1).
Loughridge, Albert, Sup't Public Schools, Newton, Iowa (21).
Loughridge, Prof. R. H., Oxford, Miss. (21).
Lovering, Prof. Joseph, Cambridge, Mass. (2).
Lupton, Prof. N. T., University of Alabama, Tuscaloosa, Ala. (17).
Lyford, Prof. Moses, Waterville, Me. (22).
Lyman, B. S., care of Smith, Archer & Co., Yokohama, Japan (15).

Lyman, Prof. Chester S., New Haven, Conn. (14).
Lyon, Dr. Henry, 34 Monument Sq., Charlestown, Mass. (18).

M.

MacArthur, Charles L., Troy, N. Y. (19).
MacIntire, Thomas, Indianapolis, Ind. (20).
Mack, Dr. William, Salem, Mass. (21).
Malone, David R., Edinburg, Ind. (20).
Mann, B. Pickman, Cambridge, Mass. (22).
Marcy, Prof. Oliver, Evanston, Ill. (10).
Marden, George H., 7 Parker St., Charlestown, Mass. (18).
Mark, Edward L., Fredonia, N. Y. (21).
Mauran, Dr. J., 68 West 19th St., New York (2).
Mayer, Prof. Albert M., Stevens Inst. Technology, Hoboken, N. J. (19).
McClintock, Frank, West Union, Iowa (22).
McCollister, Rev. S. H., Pres't Bucktel College, Akron, Ohio (22).
McCreery, J. L., Dubuque, Iowa (21).
McIsaac, P., Waterloo, Iowa (21).
McMurtrie, Horace, Boston, Mass. (17).
McMurtrie, William, Dep't Agriculture, Washington, D. C. (22).
McRae, Hamilton S., Muncie, Ind. (20.)
McRae, John, Camden, S. C. (8).
McWhorter, Tyler, Aledo, Ill. (20).
Means, Rev. A., Oxford, Ga. (5).
Meehan, Thomas, Germantown, Penn. (17).
Meek, F. B., Smithsonian Institution, Washington, D. C. (6).
Meigs, Dr. James Aitken, 423 South Broad St., Philadelphia, Penn. (12).
Mendenhall, Prof. T. C., Agri. and Mechanical Coll., Columbus, Ohio (20).
Merrill, Prof. George C., Washburn College, Topeka, Kansas (22).
Merritt, George, Indianapolis, Ind. (20).
Metcalf, Caleb B., Worcester, Mass. (20).
Miller, John A., Paducah, Ky. (22).
Milner, James W., Waukegan, Ill. (22).
Minifie, William, 114 Baltimore St., Baltimore, Md. (12).
Mitchell, Miss Maria, Vassar College, Poughkeepsie, N. Y. (4).
Moore, Prof. James W., Easton, Penn. (22).
Moore, Joseph, Pres't Earlham Coll., Richmond, Ind. (20).
Morgan, Hon. L. H., Rochester, N. Y. (11).
Morison, Dr. N. H., Provost of Peabody Institute, Baltimore, Md. (17).
Morley, Edward W., Hudson, Ohio (18).
Morris, Rev. John G., Baltimore, Md. (12).
Morris, Oran W., 242 West Twenty-sixth St., New York (19).
Morse, Prof. Edward S., Salem, Mass. (18).
Morton, Henry, Hoboken, N. J. (18).
Munroe, Charles E., Cambridge, Mass. (22).
Munroe, John C., Lexington, Mass. (22).
Munroe, William, 106 Boylston St., Boston, Mass. (18).

N.

Nason, Almond F., 15 State St., Boston, Mass. (22).
Nason, Prof. Henry B., Troy, N. Y. (18).
Newberry, Prof. J. S., Cleveland, Ohio, and Columbia Coll., New York (5).
Newcomb, Prof. Simon, U. S. Naval Observatory, Washington, D. C. (13).
Newman, John S., 48 East Washington St., Indianapolis, Ind. (20).
Newman, Mrs. John S., 48 East Washington St., Indianapolis, Ind. (21).
Newton, Hubert A., New Haven, Conn. (6).
Newton, Rev. John, Mary Esther, West Fla. (7).
Nichols, Charles A., Providence, R. I. (17).
Nichols, Prof. W. R., Mass. Inst. Technology, Boston, Mass. (18).
Nicholson, Dr. Thomas, 490 Magazine St., New Orleans, La. (21).
Nickel, George D., Connellsville, Penn. (19).
Niles, Prof. W. H., Cambridge, Mass. (16).
Norton, Miss Mary E. B., Rockford Seminary, Rockford, Ill. (21).
Norton, Prof. W. A., New Haven, Conn. (6).
Nutt, Cyrus, Bloomington, Ind. (20).

O.

Ogden, Mahlon D., Chicago, Ill. (17).
Ogden, Robert W., 44 Carondelet St., New Orleans, La. (21).
Ogden, W. B., High Bridge, Westchester County, N. Y. (17).
Oliver, Prof. James E., Cornell University, Ithaca, N. Y. (7).
Olmstead, F. L., Commissioner of Public Parks, New York (22).
Ordway, John M., Boston, Mass. (9).
Orton, Prof. Edward, President Ohio Agricultural and Mechanical College, Columbus, Ohio (19).
Osborne, Amos O., Waterville, N. Y. (19).
Osborne, John W., Washington, D. C. (22).
Ostrander, L. A., Dubuque, Iowa (21).
Owen, Dr. Richard, Ind. State University, Bloomington, Ind. (20).

P.

Packard, Dr. A. S., jr., Peabody Academy of Science, Salem, Mass. (16).
Page, Peter, Chicago, Ill. (17).
Paine, Charles, 163 Prospect St., Cleveland, Ohio (22).
Paine, Cyrus F., Rochester, N. Y. (12).
Paine, Nathaniel, Worcester, Mass. (18).
Painter, Minshall, Lima, Penn. (7).
Palfrey, Hon. C. W., Salem, Mass. (21).
Palmer, Dr. A. B., Ann Arbor, Mich. (21).
Palmer, Mrs. A. B., Ann Arbor, Mich. (21).
Palmer, Rev. Benj. M., Box 1762, New Orleans, La. (21).
Palmer, Dr. Edward, care Smithsonian Inst., Washington, D. C. (22).
Palmer, Rev. James M., Portland, Me. (22).
Parker, J. B., Grand Rapids, Mich. (21).

Parry, Dr. Charles C., Davenport, Iowa (6).
Parvin, Theodore S., Iowa City, Iowa (7).
Patton, William W., Chicago, Ill. (18).
Peck, W. A., care Peck and Hillman, Troy, N. Y. (19).
Peckham, S. F., Buchtel College, Akron, Ohio (18).
Pedrick, Wm. R., Lawrence, Mass. (22).
Peirce, Prof. Benjamin, Cambridge, Mass. (1).
Peirce, B. O., Beverly, Mass. (18).
Percival, Rev. Chester S., Rector of Emmanuel Church, Rockford, Ill. (21).
Perkins, Prof. George H., Burlington, Vt. (17).
Perkins, Prof. George R., Utica, N. Y. (7).
Perkins, Maurice, Schenectady, N. Y. (15).
Perkins, S. E., jr., Indianapolis, Ind. (20).
Perkins, T. Lyman, Salem, Mass. (22).
Phelps, Gen. Charles E., Baltimore, Md. (13).
Phelps, Mrs. Lincoln, Baltimore, Md. (13).
Phippen, George D., Salem, Mass. (18).
Pickering, Prof. Edward C., Boston, Mass. (18).
Pierce, Henry D., Indianapolis, Ind. (20).
Pond, Erasmus A., Rutland, Vt. (22).
Porteous, John, Agent Grand Trunk Railway, Portland, Me. (22).
Pourtales, L. F., Keeper Museum Comp. Zoology, Cambridge, Mass. (1).
Pratt, William H., Davenport, Iowa (17).
Prince, Gen. Henry, Paymaster General of Coast Survey, New York (22).
Preston, W. C., Iowa City, Iowa (21).
Pruyn, John V. L., Chancellor University of N. Y., 13 Elk St., Albany, N. Y. (1).
Pulsifer, Sidney, Peoria, Ill. (21).
Pumpelly, Prof. Raphael, Newburgh, Orange County, N. Y. (17).
Putnam, F. W., Director Peabody Academy Science, Salem, Mass. (10).
Putnam, Mrs. F. W., Salem, Mass. (19).

Q.

Quimby, Prof. E. T., Hanover, N. H. (22).
Quinche, Prof. A. J., Oxford, Miss. (20).
Quincy, Edmund, jr., 3 Mt. Vernon St., Boston, Mass. (11).

R.

Rauch, Dr. J. H., Chicago, Ill. (11).
Raymond, R. W., Box 4404, New York, N. Y. (15).
Read, Ezra, Terre Haute, Ind. (20).
Redfield, John H., care of A. Whitney & Sons, Philadelphia, Penn. (1).
Remsen, Prof. Ira, Williams College, Williamstown, Mass. (22).
Rice, Prof. William N., Middletown, Conn. (18).
Richards, Prof. Robert H., Mass. Inst. of Technology, Boston, Mass. (22).
Richardson, F. C. A., Corner Garrison and Wash. Av., St. Louis, Mo. (20).
Riley, Prof. Charles V., St. Louis, Mo. (17).

Ritchie, E. S., Boston, Mass. (10).
Robertson, Col. Robert S., Fort Wayne, Ind. (20).
Robertson, Thomas D., Rockford, Ill. (10).
Rockwell, Alfred P., Office Board Fire Commissioners, Boston, Mass. (10).
Rockwell, Joseph P., Burlington, Iowa (17).
Rockwood, Prof. Charles G., jr., Brunswick, Me. (20).
Rogers, Fairman, 202 West Rittenhouse Sq., Philadelphia, Penn. (11).
Rogers, Prof. Robert E., Philadelphia, Penn. (18).
Rogers, W. A., Cambridge, Mass. (15).
Rogers, Prof. William B., Hotel Berkeley, Boston, Mass. (1).
Rominger, Dr. Carl, Ann Arbor, Mich. (21).
Rood, Prof. O. N., New York (14).
Roosevelt, Clinton, No. 15 Centre St., New York (11).
Ross, Dr. Alexander M., Toronto, Canada (21).
Ross, Angus, Morris Street School, Halifax, Canada (22).
Rosseter, G. R., Marietta, Ohio (18).
Rumsey, Bronson C., Buffalo, N. Y. (15).
Runkle, Prof. J. D., Pres. Institute of Technology, Boston, Mass. (2).
Russell, L. W., Providence, R. I. (20).
Rutherford, Louis M., New York (13).

S.

Sadtler, Prof. Samuel D., Gettysburg, Penn. (22).
Safford, James M., Nashville, Tenn. (6).
Safford, Dr. Mary J., 4 Boylston Place, Boston, Mass. (21).
Sanders, Benjamin D., Wellsburg, Brooke County, W. V. (19).
Saunders, William, London, Canada (17).
Saunderson, Robert, Sup't of Public Schools, Burlington, Iowa (21).
Saville, Dr John J., Sioux City, Iowa (22).
Scammon, J. Young, Chicago, Ill. (17).
Schanck, Prof. J. Stillwell, Princeton College, Princeton, N. J. (4).
Schott, Charles A., Coast Survey Office, Washington, D. C. (8).
Scudder, Samuel H., Cambridge, Mass. (13).
Seaman, Ezra C., Ann Arbor, Mich. (20).
Seely, Charles A., 26 Pine St., New York (18).
Senter, Harvey S., Aledo, Mercer Co., Ill. (20).
Seymour, Prof. William P., 105 Third St., Troy, N. Y. (19).
Shaler, Prof. N. S., Newport, Ky., and Cambridge, Mass. (19).
Sheafer, P. W., Pottsville, Penn. (4).
Sheldon, Edwin H., Chicago, Ill. (17).
Sias, Solomon, Charlottesville, Schoharie Co., N. Y. (10).
Sill, Hon. Elisha N., Cuyahoga Falls, Ohio (6).
Silliman, Prof. Benjamin, New Haven, Conn. (1).
Silliman, Prof. Justus M., Easton, Penn. (19).
Sloan, Dr. John, New Albany, Ind. (20).
Smith, Prof. Eugene A., University of Alabama, Tuscaloosa, Ala. (20).
Smith, Prof. J. L., Louisville, Ky. (14).

Smith, Dr. J. W., Charles City, Iowa (21).
Smith, James Y., 56 Westminster St., Providence, R. I. (9).
Smith, S. I., New Haven, Conn. (18).
Snell, Prof. Ebenezer S., Amherst, Mass. (2).
Spencer, John W., Paxton, Ind. (20).
Squier, Hon. E. G., 4 West Twenty-seventh St., New York (18).
Stanard, Benjamin A., Cleveland, Ohio (6).
Starr, William, Ripon, Wis. (21).
Stearns, R. E. C., San Francisco, Cal. (18).
Steiner, Dr. Lewis H., Frederick City, Md. (7).
Stephens, W. Hudson, Lowville, N. Y. (18).
Stevens, Julius, Humboldt, Iowa (21).
Stevens, R. P., 26 Pine St., New York (18).
Stevens, Dr. Thaddeus M., Indianapolis, Ind. (20).
Steward, A., 631 York St., Chicago, Ill. (21).
Stimpson, Thomas M., Peabody, Mass. (18).
Stockwell, John N., 579 Case Av., Cleveland, Ohio (18).
Stone, Mrs. Lander, Chicago, Ill. (22).
Stone, Col. Samuel, Box 203, Chicago, Ill. (17).
Storer, Dr. D. H., Boston, Mass. (1).
Storer, Dr. Frank H., Boston, Mass. (13).
Storke, Helen L., Auburn, N. Y. (19).
Storrs, Henry E., Jacksonville, Ill. (20).
Stowell, John, 48 Main Street, Charlestown, Mass. (21).
Stuart, Prof. A. P. S., Ill. Industrial University, Champaign, Ill. (21).
Sutton, George, Aurora, Ind. (20).
Swain, James, Fort Dodge, Iowa (21).
Swain, Mrs. James, Fort Dodge, Iowa (21).
Swallow, Prof. G. C., Columbia, Mo. (10).
Swan, Prof. Richard W., Iowa College, Grinnell, Iowa (21).
Swan, S. E., Brooklyn, N. Y. (22).
Swasey, Oscar F., Beverly, Mass. (17).

T.

Taft, Prof. S. H., President Humboldt College, Humboldt, Iowa (21).
Taft, Mrs. S. H., Humboldt, Iowa (21).
Talbot, Hon. George F., Portland, Me. (22).
Tappan, Eli T., Pres't of Kenyon College, Gambier, Ohio (20).
Taylor, Edward R., Cleveland, Ohio (20).
Tenney, Prof. Sanborn, Williamstown, Mass. (17).
Tewksbury, Samuel H., Portland, Me. (22).
Thompson, Aaron R., 36 Pine St., New York (1).
Thompson, Mrs. Elizabeth, 46 West Tenth St., New York (22).
Thompson, Harvey M., Box 149, Chicago, Ill. (17).
Thompson, Joseph P., Portland, Me. (22).
Thompson, Robert H., Troy, N. Y. (19).
Thomson, A., Iowa City, Iowa (21).

Thrasher, William M., Indianapolis, Ind. (21).
Thurber, Miss Elizabeth, Plymouth, Mass. (22).
Tillman, Prof. S. D., Jersey City, N. J. (15).
Tillman, Mrs. S. D., Jersey City, N. J. (20).
Todd, Prof. James E., Tabor, Fremont Co., Iowa (22).
Tolles, Robert B., 40 Hanover St., Boston, Mass. (15).
Tomlinson, Dr. J. M., 28 East Ohio St., Indianapolis, Ind. (20).
Townsend, Hon. Franklin, Albany, N. Y. (4).
Townshend, Prof. N. S., Columbus, Ohio (17).
Tracy, C. M., Lynn, Mass. (19).
Trembly, Dr. J. B., San Jose, Santa Clara Co., Cal. (17).
Trowbridge, Mrs. L. H., 158 Jefferson Ave., Detroit, Mich. (21).
Trowbridge, Prof. W. P., New Haven, Conn. (10).
Turnbull, Dr. Lawrence, 1208 Spruce St., Philadelphia, Penn. (10).
Turner, Dr. Robert S., box 712½, Minneapolis, Minn. (18).
Tuttle, Prof. Albert H., Columbus, Ohio (17).
Twining, A. C., New Haven, Conn. (18).
Tyson, Prof. Philip T., Baltimore, Md. (12).

U.

Uhler, Philip R., Baltimore, Md. (19).
Upham, Dr. J. Baxter, 31 Chestnut St., Boston, Mass. (14).

V.

Vail, Prof. Hugh D., 1927 Mt. Vernon St., Philadelphia, Penn. (18).
Van der Weyde, Dr. P. H., New York (17).
Vasey, George, Department of Agriculture, Washington, D. C. (20).
Vaux, William S., 1702 Arch St., Philadelphia, Penn. (1).
Verrill, Prof. A. E., Yale College, New Haven, Conn. (16).
Vose, Prof. George L., Bowdoin College, Brunswick, Me. (15).

W.

Waddel, John N., Oxford, Miss. (17).
Walker, Charles A., 42 Court St., Boston, Mass. (18).
Walker, George C., 274 Michigan Ave., Chicago, Ill. (17).
Walker, Prof. Joseph B., care Bank of Kentucky, Louisville, Ky. (20).
Walker, Prof. J. R., Napoleon Ave., corner Coliseum St., New Orleans, La. (19).
Walker, N. B., Arlington, Mass. (20).
Walling, H. F., 102 Chauncy St., Boston, Mass. (16).
Wanzer, Ira, Lanesville, Litchfield Co., Conn. (18).
Ward, Prof. Henry A., Rochester, N. Y. (13).
Ward, Dr. R. H., No. 53 Fourth St., Troy, N. Y. (17).
Warder, Robert B., Cleves, Hamilton Co., Ohio (19).
Wardwell, George J., Rutland, Vt. (20).
Warner, H. C., Clermont, Iowa (21).
Warner, James D., 4 Hanover St., New York (18).
Warner, Mrs. J. D., 4 Hanover St., New York (21).
Warren, Gen. G. K., U.S.A., Engineer's Office, Newport, R. I. (12).

Warren, G. W., 42 Court St., Boston, Mass. (18).
Warren, S. Edward, Institute of Technology, Boston, Mass. (17).
Watson, Sereno, Botanic Gardens, Cambridge, Mass. (22).
Waugh, J. W., Lucknow, India (21).
Webb, Benjamin, Salem, Mass. (18).
Webster, Prof. Nathan B., Prin. of Webster Institute, Norfolk, Va. (7).
Welch, Mrs. G. O., Lynn, Mass. (21).
Wells, Daniel H., New Haven, Conn. (18).
Wells, George A., Troy, N. Y. (19).
Westcott, O. S., High School, Chicago, Ill. (21).
Wheatland, Dr. Henry, President Essex Institute, Salem, Mass. (1).
Wheatley, Charles M., Phœnixville, Penn. (1).
Wheeler, C. G., Chicago, Ill. (18).
Wheeler, Dr. T. B., Box 38½, Montreal, Canada (11).
Wheelock, G. A., Keene, N. H. (22).
Wheildon, W. W., Concord, Mass. (13).
White, Prof. C. A., Bowdoin College, Brunswick, Me. (17).
Whitfield, R. P., Albany, N. Y. (18).
Whitney, Asa, care of A. Whitney & Sons, Philadelphia, Penn. (1).
Whitney, Prof. J. D., Cambridge, Mass. (1).
Whitney, Mary W., Waltham, Mass. (19).
Whitney, Solon F., Watertown, Mass. (20).
Whittlesey, Col. Charles, Cleveland, Ohio. (1).
Wilber, G. M., Pine Plains, N. Y. (19).
Wilder, Dr. Burt G., Cornell University, Ithaca, N. Y. (22).
Wiley, Dr. Harvey W., Indianapolis, Ind. (21).
Williams, Charles H., 15 Arlington St., Boston, Mass. (22).
Williams, Mrs. E. B., Strawberry Point, Iowa (21).
Williams, H. S., Williams Brothers, Phenix Iron Works, Ithaca, N. Y. (18).
Williams, Prof. Henry W., Boston, Mass. (11).
Winchell, Prof. Alexander, Syracuse, N. Y. (3).
Winchell, Prof. N. H., St. Anthony, Minn. (19).
Witter, F. M., Muscatine, Iowa (21).
Woodman, H. T., Dubuque, Iowa (20).
Woodworth, Dr. John M., U. S. Marine Hospital Service, Washington, D. C. (17).
Wormley, Thomas G., Columbus, Ohio (20).
Worster, Joseph, 115 East Thirtieth St., New York (22).
Worthen, A. H., Springfield, Ill. (5).
Wright, Prof. A. W., Yale College, New Haven, Conn. (14).
Wurtele, Rev. Louis C., Acton Vale, Province of Quebec, Canada East (11).
Wurtz, Henry, 12 Hudson Terrace, Hoboken, N. J. (10).
Wyckoff, William C., Tribune Office, New York (20).
Wylie, Prof. Theophilus A., Ind. State University, Bloomington, Ind. (20).

Y.

Youmans, Prof. E. L., New York (6).
Young, Prof. Charles A., Dartmouth College, Hanover, N. H. (18).
Young, William H., 8 and 9 First St., Troy, N. Y. (19).

MEMBERS ELECTED

AT

PORTLAND MEETING.

One hundred and ten members were elected at the Portland meeting. Of these ninety-seven have paid the admission fee and assessment for the meeting and their names have been incorporated into the List of Members. One has declined, and the following have not yet replied to the notifications sent to them.

Burton, Charles H., Superintendent Schools, Plymouth, Mass.
Chace, Arnold B., Valley Falls, R. I.
Davis, William T., Plymouth, Mass.
Hayes, Rev. Charles W., Portland, Me.
Kingsbury, Hon. Benjamin, Jr., Portland, Me.
Muir, John, Yosemite, Cal.
Neely, Rt. Rev. Henry A., Portland, Me.
Schwarz, Rev. Louis B., Boston, Mass.
Smith, Louis B., Portland, Me.
Snyder, Dr. John F., Virginia, Cass Co., Ill.
Whitaker, Nelson Bowen, Providence, R. I.
Wildes, Rev. Dr. George D., New York, N. Y.

DECEASED MEMBERS.

Adams, C. B., Amherst, Mass. (1).
Adams, Edwin F., Charlestown, Mass. (18).
Agassiz, Louis, Cambridge, Mass. (1).
Ames, M. P., Springfield, Mass. (1).
Appleton, Nathan, Boston, Mass. (1).

Bache, Alexander D., Washington, D. C. (1).
Bailey, J. W., West Point, N. Y. (1).
Beck, C. F., Philadelphia, Penn. (1).
Beck, Lewis C., New Brunswick, N. J. (1).
Beck, T. Romeyn, Albany, N. Y. (1).
Binney, Amos, Boston, Mass. (1).
Binney, John, Boston, Mass. (3).
Blanding, William, R. I. (1).
Blatchley, Miss S. L., New Haven, Conn. (19).
Bomford, George, Washington, D. C. (1).
Burnap, G. W., Baltimore, Md. (12).
Burnett, Waldo I., Boston, Mass. (1).
Butler, Thomas B., Norwalk, Conn. (10).

Carpenter, Thornton, Camden, S. C. (7).
Carpenter, William M., New Orleans, La. (1).
Case, William, Cleveland, Ohio (6).
Chapman, N., Philadelphia, Pa. (1).
Chase, S., Dartmouth, N. H. (2).
Chauvenet, William, St. Louis, Mo. (1).
Clapp, Asahel, New Albany, Ind. (1).
Clark, Joseph, Cincinnati, Ohio (5).
Cleveland, A. B., Cambridge, Mass. (2).
Coffin, Prof. James H., Easton, Penn. (1).
Cole, Thomas, Salem, Mass. (1).
Coleman, Henry, Boston, Mass. (1).
Corning, Erastus, Albany, N. Y. (6).
Crosby, Thomas R., Hanover, N. H. (18).

Dean, Amos, Albany, N. Y. (6).
Dearborn, George H. A. S., Roxbury, Mass. (1).
Dekay, James E., New York (1).
Dewey, Chester, Rochester, N. Y. (1).

Dexter, G. M., Boston, Mass. (11).
Ducatel, J. T., Baltimore, Md. (1).
Dumont, A. H., Newport, R. I. (14).
Duncan, Lucius C., New Orleans, La. (10).
Dunn, R. P., Providence, R. I. (14).

Everett, Edward, Boston, Mass. (2).
Ewing, Hon. Thomas, Lancaster, Ohio (5).

Ferris, Rev. Dr. Isaac, New York (6).
Fisher, Mark, Trenton, N. J. (10).
Fitch, Alexander, Hartford, Conn. (1).
Forbush, E. B., Buffalo, N. Y. (15).
Foster, Col. J. W., Hyde Park, Chicago, Ill. (1).
Foucon, Felix, Madison, Wis. (18).
Fox, Charles, Grosse Ile, Mich. (7).

Gay, Martin, Boston, Mass. (1).
Gibbon, J. H., Charlotte, N. C. (3).
Gillespie, W. M., Schenectady, N. Y. (10).
Gilmor, Robert, Baltimore, Md. (1).
Gould, Augustus A., Boston, Mass. (11).
Gould, B. A., Boston, Mass. (2).
Graham, James D., Washington, D. C. (1).
Gray, James H. Springfield, Mass. (6).
Greene, Benjamin D., Boston, Mass. (1).
Griffith, Robert E., Philadelphia, Penn. (1).

Hackley, Charles W., New York (4).
Hale, Enoch, Boston, Mass. (1).
Hare, Robert, Philadelphia, Penn. (11).
Harlan, Joseph G., Haverford, Penn. (8).
Harlan, Richard, Philadelphia, Penn. (1).
Harris, Thaddeus W., Cambridge, Mass. (1).
Hart, Simeon, Farmington, Conn. (1).
Hayden, H. H., Baltimore, Md. (1).
Hayward, James, Boston, Mass. (1).
Hitchcock, Edward, Amherst, Mass. (1).
Holbrook, J. E., Charleston, S. C. (1).
Hopkins, Albert, Williamstown, Mass. (19).
Horton, William, Craigville, Orange Co., N. Y. (1).
Houghton, Douglas, Detroit, Mich. (1).
Howland, Theodore, Buffalo, N. Y. (15).
Hubbert, James, Richmond, Province of Quebec (16).
Hunt, E. B., Washington, D. C. (2).
Hunt, Freeman, New York (11).

Ives, Thomas P., Providence, R. I. (10).

Johnson, W. R., Washington, D. C. (1).
Jones, Catesby A. R., Washington, D. C. (8).

Lasel, Edward, Williamstown, Mass. (1).
Lederer Baron von, Washington, D. C. (1).
Lieber, Oscar M., Columbia, S. C. (8).
Lincklaen, Ledyard, Cazenovia, N. Y. (1).
Linsley, James H., Stafford, Conn. (1).
Loosey, Charles F., New York (12).
Lothrop, Joshua R., Buffalo, N. Y. (15).
Lyon, Sidney S., Jeffersonville, Ind. (20).

Maack, G. A., Cambridge, Mass. (18).
M'Conihe, Isaac, Troy, N. Y. (4).
Marsh, Dexter, Greenfield, Mass. (1).
Mather, William W., Columbus, Ohio (1).
Meade, George G., Philadelphia, Pa. (15).
Morton, S. G., Philadelphia, Penn. (1).

Newton, E. H., Cambridge, N. Y. (1).
Nicollett, J. N., Washington, D. C. (1).
Norton, J. P., New Haven, Conn. (1).
Noyes, J. O., New Orleans, La. (21).

Oakes, William, Ipswich, Mass. (1).
Olmsted, Alexander F., New Haven, Conn. (4).
Olmsted, Denison, New Haven, Conn. (1).
Olmsted, Denison, Jr., New Haven, Conn. (1).

Parkman, Samuel, Boston, Mass. (1).
Perkins, Henry C., Newburyport, Mass. (18).
Perry, John B., Cambridge, Mass. (16).
Perry, M. C., New York (10).
Plumb, Ovid, Salisbury, Conn. (9).
Pope, Charles A., St. Louis, Mo. (12).
Porter, John A., New Haven, Conn. (14).
Pugh, Evan, Centre Co., Penn. (14).

Redfield, William C., New York (1).
Rockwell, John A., Norwich, Conn. (10).
Rogers, James B., Philadelphia, Penn. (1).

Seward, William H., Auburn, N. Y. (1).
Silliman, Benjamin, New Haven, Conn. (1).
Smith, J. V., Cincinnati, Ohio (5).
Smith, Lyndon A., Newark, N. J. (9).
Sparks, Jared, Cambridge, Mass. (2).

Stimpson, Dr. William, Chicago, Ill. (12).
Sullivant, Prof. W. S., Columbus, Ohio (7).

Tallmadge, James, New York (1).
Taylor, Richard C., Philadelphia, Penn. (1).
Teschemacher, J. E., Boston, Mass. (1).
Thompson, Z., Burlington, Vt. (1).
Thurber, Isaac, Providence, R. I. (9).
Torrey, John, New York (1).
Totten, J. G., Washington, D. C. (1).
Townsend, John K., Philadelphia, Penn. (1).
Troost, Gerard, Nashville, Tenn. (1).
Tuomey, M., Tuscaloosa, Ala. (1).
Tyler, Edward R., New Haven, Conn. (1).

Vancleve, John W., Dayton, Ohio (1).
Vanuxem, Lardner, Bristol, Penn. (1).

Wadsworth, James S., Genesee, N. Y. (2).
Wagner, Tobias, Philadelphia, Penn. (9).
Walker, Joseph, Oxford, N. Y. (10).
Walker, Sears C., Washington, D. C. (1).
Walker, Timothy, Cincinnati, Ohio (4).
Warren, John C., Boston, Mass. (1).
Webster, H. B., Albany, N. Y. (1).
Webster, J. W., Cambridge, Mass. (1).
Webster, M. H., Albany, N. Y. (1).
Wheatland, Richard H., Salem, Mass. (13).
Willard, Emma, Troy, N. Y. (15).
Woodbury, L., Portsmouth, N. H. (1).
Wright, John, Troy, N. Y. (1).

Young, Ira, Hanover, N. H. (7).

ADDRESS

OF

DR. J. LAWRENCE SMITH,

THE RETIRING PRESIDENT OF THE ASSOCIATION.

Fellow Associates:—We meet again, at a point far distant from the one where we gathered last year, to interchange social greetings and scientific thoughts, and to form plans for future labor and usefulness. Fifteen hundred miles divide Dubuque from Portland, as the bird flies, and yet that extent of country and much more are all our own. Its living and its dead treasures, with its rocks and its soil, furnish our men of science abundant study from which to draw rich stores of knowledge, and to direct the capital of the country to new sources of wealth.

As the members of the American Association for the Advancement of Science hold their session for a few days only, and occupy a portion of their time in interchange of social greetings among themselves and with the inhabitants of the city where they meet, that critical examination of papers communicated to the Association cannot be entered upon that otherwise would be, nor can the length of the communications and discussions be easily limited. In fact, while it would be desirable to supervise these matters more fully, such supervision is surrounded with so many difficulties that those whose business it is are forced to content themselves with an imperfect discharge of their duty.

This too often gives rise to unjust criticisms on the part of the press, whose reporters attend the meetings with the same views as those with which they would enter a learned body of scientific men, who meet at stated periods, with short intervals, and where both time and sound criticism are bestowed upon such investigations as are communicated.

The meeting of this Association is, in some sense, to be regarded as an annual scientific *fête*, where the interchange of ideas outside the audience-room suggests as much, if not more, stern matter for reflection as the communications which may be read; minds that have been on the stretch during the year are relaxed, and fresh pabulum and new vigor are furnished for the coming year.

It sometimes happens that many persons who attend our meetings gather from them erroneous impressions as to what the scientific men of the country are doing, and go away questioning themselves whether or not scientific societies and associations have, after all, done much for science; and conclude that while the men forming them have made many important investigations, and published them for the benefit of succeeding ages, it is to practical and obscure persons that the world is indebted for its great discoveries.

I allude to this here, as it is but recently that I have seen this assertion made in an article calculated to attract the attention of the masses, and the author of that article illustrates the fact by citing Clarke, Fulton and Morse. Now, while all honor is due to those men of skill and genius, I would ask—What gave them the fulcrums on which they placed their levers, by which they have wrought so much in practical science and the arts of life? *It was pure science.* Without its aid Clarke's practical skill would have failed him in constructing his huge astronomical lenses; it is to the experiments on latent heat in the laboratory of Black that we owe the present steam-engine, and without which Fulton would never have ruffled the water of our rivers nor stemmed the winds of the ocean; and without the scientific thought and the grand, though inconspicuous, experiments of Galvani, Volta, Oersted, Faraday, Henry and others, no one would have ever dreamed of making a swift messenger of the lightning.

My thoughts on this subject have led me to reflect much upon scientific training in this country, for those wishing to pursue science as a profession as well as for those desiring it only for general education.

There are, no doubt, serious errors in the scientific training that students undergo at our various universities and schools, which are too much in the habit of making short cuts in going over the fields of science. We are in fact a fast people, as it is commonly expressed, and are not content to devote patient and laborious study to pursuits that can be mastered only in that way. A short time ago a physician writing on this same error in relation to his profession justly said that, while we have shortened distance by the railroad and the telegraph, the road to learning is the same as it was in the days of Socrates and Plato.

The student is restless to become instructor, the lecture-room enticing him from his studies before they are half mastered; consequently his instruction to others is both meagre and imperfect.

Our vast material interests draw the students from their laboratories to undertake the conducting of mines and other important works. The consequence is, bad economy reigns in most of them; and if it were not for the patient submission of the people of this country to high prices, many an enterprise would have to suspend operations.

But it is at the door of the educational institutions themselves that the greatest blame is to be placed. First of all, our universities (or rather our so-called universities) are too numerous. Nowadays every college must have a scientific school attached, else it is not thought complete; and the number of professors competent to fill the scientific chairs in all these institutions could not be easily supplied in this country. Were it possible, it would be far better to have fewer scientific schools; to establish them on the broadest basis, with most liberal endowments, so that instruction could be imparted at some mere nominal cost to the student; to make their examinations of such a standard that the indorsement of these several schools would be a passport to the bearer of it wherever he might seek for employment in pure science or in its applications; and, furthermore, by a system of well-endowed scholarships, to retain those specially gifted with taste and talent for pure science to devote their first years to labor in that direction. Owing to these defects in our system of scientific education, American science is frequently reproached as being very deficient in pure and patient research.

Now, while admitting that our scientists have fallen short of what might have been expected of them, no one can deny that a

vast amount of scientific labor has been accomplished in this country from the time of Franklin to the present day; and in the application of science to the arts we are not far behind the most advanced nation of our own time.

I know that American scientists are looked upon by their European colleagues as in some sense piratical in their nature, simply capturing the hard-earned labors of others, applying the great truths and discoveries in science that others have brought to light, and not evolving them by hard and laborious study and experiment. This is to some extent true, for the labors required of our professors, who have educated and trained minds, in the countless colleges that dot the land, are so onerous that no time is given them for the exercise of original thought and investigation.

What can a physicist, a chemist or a naturalist, do who has three or four classes to teach, usually in the most elementary part of their studies? This very labor unfits him for that free exercise of the mind which leads to new ideas and discoveries. He becomes an educational drudge instead of an intellectual scientist; and whatever his intrinsic merits may be, he is in most cases sustained, pecuniarily, no better than those engaged in the commonest pursuits of life, being at the same time restricted in intellectual resources — such as books, scientific transactions, apparatus, etc.

I will, however, just here make one other plea for our men of science against any unjust comparison with those across the Atlantic. It is this. Our country is a new one, of most peculiar and wonderful features of surface, of soil and of climate, and of untold and fabulous wealth within its bowels; it beckons every man to fortune; and with such ease are wealth and honors snatched from its overflowing lap that even men who love and honor science are drawn off their direct paths into by-ways and other pursuits, and too often leave behind them the scientific toga, which is never again assumed. In Europe it is otherwise; no temptations of this kind beset the scientist, and he delves into scientific lore, acquiring great ideas and telling them to the world, exciting their wonder; and even then the honors they acquire only bind them faster to their closets, for they are not tempted as we are.

In later years the liberality of wealthy patrons of learning and science has done much to advance pure science in this country by enabling the young and enthusiastic pursuers after nature's secrets to give full scope to their tastes, and thus has opened to them new

fields of research so enticing that their entire lives may become absorbed in them. This is increasing every day in our country, and before very long there will be such inducements offered to her greater minds to devote their lives to pure science that America will become as prolific as Europe in new scientific ideas and discoveries.

Let us ever bear in mind that it is *abstract scientific ideas which underlie, in these modern days, all discoveries conducive to man's progress*, from the making of a pen to the construction of a telescope; or, as Herbert Spencer well expresses it, "each machine is a theory before it becomes a concrete fact." The man of pure science paves the way, erects the mile-stones, and puts up the guide-post for the practical man. The world, long dormant to this great truth, is fast waking up to its acknowledgment; as those words *Cui bono?* (the touch-stone used by the so-called practical men) are only heard now in faint whispers, where they were formerly sounded most clamorously whenever any scientific discovery was announced.

This does not arise from any change in men; they are the same now as they were in the days of Galvani, who was doubtless regarded as a frivolous fellow, engaged in his daily experiments over the convulsions of the muscles in a frog's leg when brought in contact with two metals; but, while mankind has not changed, Galvani's experiment has, and instead of a frog, it is now a world that is convulsed by the electric force then discovered, as this same electricity flashes through those nerves of metal that stretch across land and river and bury themselves deep beneath the oceans of our globe; battles are fought, victories announced, commerce controlled, and, I am sorry to say, tyranny abetted, by that wonderful agent whose phenomena in their incipiency invited the ridicule of the ordinary observer.

Science at the present day commands the respect of the world; nations, looking up to it, seek its advice at all times, and move in no material enterprises without consulting its oracles; yellow-covered literature is beginning to find a rival in well-conducted popular scientific journals and popular treatises on the various branches of science.

As an association of American scientists, we are looked upon as men representing science in all its bearings upon the physical and mental world, and some even go so far as to suppose that we

would arrogate to represent its bearings equally upon the spiritual world. This being the case, it behooves us to guard well our thoughts, words and acts, lest they do science and ourselves injustice, and misrepresent both nature and nature's God.

We are all searchers after truth: but let us be careful that we do not mistake what truth is, and be beguiled into following some fatal error which has simply borrowed the garb of truth, and completely enveloped itself in it, so as to hide its own deformity. Error has often glimmer enough to dazzle the sickly eye of the enthusiast; truth itself shines with sufficient brightness to be seen by the most jealous among scientists.

While it would not be out of place to review the activity of American science for the benefit of the general public, yet it would occupy too much time, and I will merely refer to it to show that our Government is fully alive to the value of well-directed scientific labors. The Government never hesitates to encourage the most thorough investigations by scientific men into all matters that are likely to benefit the people or advance those great scientific investigations which are of a more abstract character. Witness the care and liberality with which it encourages that corps of scientists engaged in the gigantic enterprise of the coast survey in all its various departments; its liberal appropriation of money and means for the observation of those great astronomical phenomena, such as solar eclipses, the transit of Venus, etc., which, while they may not be attended with any immediate material advantage to the Government, yet serve to instruct our people in those higher and nobler aspirations after great natural truths which must inevitably result in unfolding to us the riches of our land, teeming with every diversified beauty of mountain, valley, and plain, seas, lakes, and rivers, and, beneath her surface, with all the variety of wealth that nature seems to have been able to produce. While the older portions of the world are making serious calculations, and even looking forward with gloomy forebodings to the time when their soil and rocks will cease to give wealth to toil, our soil and our rocks are but just being turned up to reveal wealth tenfold greater than the world ever knew before. But in the midst of all this abundance let us feel assured of one thing; it is so placed that no sluggard can stretch forth his hand and partake of it.

The wealth of America means toil. And perhaps in this we are even more blessed than we sometimes are disposed to think;

for from the rich soil which covers such a vast proportion of our country, some of the states of which, like Illinois, with 55,000 square miles of surface, have hardly a barren acre, yet we can pluck nothing; it is not like the tropical forest, from which the indolent natives may gather their food, and live a life of inertia almost akin to that of the beasts that wander through its rich foliage. In this country the arm must be stretched forth, the forest felled, the ground ploughed, provision made against the inclemency of varying seasons, but when this is done what a glorious return!—rich and luxuriant crops, abundant harvests. Then, by the numerous navigable streams and favorable surface for roads, a ready market is afforded for the farmer's surplus. And when we go beneath the soil and mine the rock it is not only the uncertain gold and silver, but the sure coal and iron that reward toil, and from the very nature of the labor improve those engaged in it.

As followers and patrons of science we must keep in view the wants and wishes of the people. Sometimes the people themselves, as well as their representatives, are slow to appreciate our labors; but experience has proved that they give way at last to the patient and judicious perseverance of men of science, who in some way or other show that they are not mere abstractionists, but that what they do has practical bearings, and therefore renders the people more powerful both at home and abroad. Science furnishes, so to speak, the raw material out of which all the progress of modern nations is constructed. To use the words of one of our Nestors of science: "It is only in recent times that the value of scientific research began to be felt; and I hope to live, old as I am, long enough to see the community, the enlightened community which has become my second fatherland, appreciate what science is doing for the general prosperity, and then contribute to the necessities of science with that generous liberality which characterizes the acts of American people."

Thus much has been said in reference to science in America, acknowledging our shortcomings and attempting to correct certain erroneous impressions, both in America and abroad, in regard to the labor of scientists in this country. It may appear an attempt on my part to urge undue excuses; such certainly is far from my intention, which is to do simple justice to those prosecuting science under more or less disadvantageous circumstances.

I now pass to the second part of my discourse—the methods of modern science—the caution to be observed in pursuing it, if we do not wish to pervert its end by too confident assertions and deductions.

It is a very common attempt nowadays for scientists to transcend the limits of their legitimate studies; and in doing this they run into speculations apparently the most unphilosophical, wild and absurd; quitting the true basis of inductive philosophy, and building up the most curious theories on little else than assertion; speculating upon the merest analogy; adopting the curious views of some metaphysicians, like Edward Von Hartmann; striving to work out speculative results by the inductive method of natural science. To me this appears a perversion of Bacon's philosophy, and we cannot wonder that one adopting such views, whatever his claim to genius may be, soon cuts loose from all physical reasoning and becomes involved in the most transcendental and to all appearances absurd opinions, which, however clear to the author, are strange and unintelligible to others; and if at any one time we believe we have caught the conception of the author, this impression is only momentary, and we give up in despair, realizing that we cannot follow his intellectual ecstasies; for, in the language of Tyndall, they are even "unthinkable." Those engaged in such speculations are very commonly found in bitter conflict with each other, forcing on us the belief of the saying of D'Alembert, that "when absurd opinions become inveterate it sometimes becomes necessary to replace them by other errors, if nothing better can be done."

This extreme metaphysical philosophy is referred to for the reason that many scientists, ranking as sober, earnest laborers after truth, are caught dealing in such philosophy in their method of investigation, and sometimes, quite unconsciously to themselves, forgetting that "science is only an accurate record of the processes of nature; that its laws are only generalizations of its observations, and not a declaration of an inherent necessity; and that one of its observations is the uniformity of natural sequence."

I am one of those who believe that everything must give way to the laws of nature; but then we must master these laws, and be sure that we have done this before either interpreting phenomena by them or venturing into the realm of speculation.

As has been already remarked, men are to-day just what they have ever been. As bright intellects and as great philosophers lived two or three thousand years ago as do now; their minds sought out the same great truths that we are searching for in these days, and they sought for them by the lights with which they were surrounded. In those earlier ages poetry, sculpture, architecture, and even some facts belonging to natural history (things that belonged either to the imagination or to the eye) arrived at as high a degree of perfection as perhaps they ever will; for the two senses which appreciate the ideal and the real were as perfect then as now.

But when man was called upon to labor in fields where the imagination and the eye aided him but little or not at all, then the discoveries in these fields and their interpretations called for other means for arriving at results. In modern days we attempt to be guided by the clear light of inductive reasoning which we may think we are employing, when too often it is the very smoky torch of analogy that is being used; and this fact serves to explain why it is that some of the most brilliant philosophers of comparatively modern days are only remembered by their names — as, for example the great French philosopher Descartes, whom Dugald Stewart says "is much better known to the learned of our day by the boldness of his exploded errors than by the profound and important truths contained in his works."

And such an example as this is of great value to the reflective mind, teaching caution, and demonstrating the fact that, while the rules by which we are guided in scientific research are far in advance of those of ancient days, we must not conclude that they are perfect by any means. In our modern method of investigation how many conspicuous examples of deception we have had in pursuing even the best method of investigation! Take, for instance, the science of geology from the time of Werner to the present day. While we always thought we had the true interpretation of the structural phenomena of the globe as we progressed from year to year, yet how vastly different are our interpretations of the present day from what they were in the time of Werner! In chemistry the same thing is true. How clearly were all things explained to the chemist of the last century by the doctrine of Phlogiston which in the present century receives no credence, while chemical phenomena are now viewed in an entirely different light!

Lavoisier, in the latter part of the last century, elucidated the phenomenon of respiration and the production of animal heat by one of the most beautiful of theories, based, to all appearances, upon well observed facts; yet at the present day more delicate observations, and the discovery of the want of balance between the inhaled oxygen and exhaled carbonic acid subverted that beautiful theory, and we are left entirely without one. It is true we have collated a number of facts in regard to respiration, molecular changes in the tissues, etc., all of which are recognized as having something to do with animal heat; still it is acknowledged that we are incapable of giving any concrete expression to the phenomenon of respiration and animal heat as Lavoisier did eighty or ninety years ago.

Electricity is the same now as it has ever been, yet it was once spoken of as a fluid, then as a force, now as an energy readily convertible into caloric or mechanical energy; and in what light it will be considered fifty years hence no one can predict.

Now what I desire to enforce here is that, amid all these changes and revolutions of theories, so called, it is simply man, the interpreter, that has erred, and not nature; her laws are the same; we simply have not been able to read them correctly, and perhaps never shall be.

What, it may be asked, are we to do then? Must we cease theorizing? Not at all. The lesson to be learned from this is, to be more modest in our generalizations; to generalize as far as our carefully made out facts will permit us, and no farther; to check the imagination and not to let it run riot and shipwreck us upon some metaphysical quicksand.

The fact is, it becomes a question whether there is such a thing as a pure theory in science. No true scientific theory deserves the name that is not based on verified hypotheses; in fact, it is but a concise interpretation of the deductions of scientific facts. Dumas has well said that theories are like crutches, the strength of them to be tested by attempting to walk with them. And I might farther add that very often scientists, who are without sure-footed facts to carry them along, take to these crutches.

It is common to speak of the theory of gravitation, when there is nothing purely hypothetical in connection with the manner in which it is studied; in it we only see a clear generalization of observed laws which govern the mutual attraction of bodies. If at

any time Newton did assume an hypothesis, it was only for the purpose of facilitating his calculations. "Newton's passage from the falling of an apple to the falling of a moon was at the outset a leap of the imagination;" but it was this hypothesis, verified by mathematics, which gave to the so-called theory of gravitation its present status.

In regard to light, we are in the habit of connecting with it a pure hypothesis; viz., the impressions of light being produced by emission from luminous bodies, or by the undulation of an all-pervading attenuated medium; and these hypotheses are to be regarded as probable so long as the phenomena of light are explained by them, and no longer. The failure to explain one single well-observed fact is sufficient to cast doubt upon or subvert any pure hypothesis, as has been the case with the emission theory of light, and may be the fate of the undulatory theory, which, however, up to the present time serves in all cases.

A theory or scientific speculation, to possess any great weight, must receive universal assent by those minds capable of investigating the subject. Thus the undulatory theory of light is universally accepted as representing the true nature of the operation of light, so far as we are now able to interpret its phenomena.

Zoölogists equally learned will agree perfectly as regards the physical structure of an ape and a man, and thus far their results are entitled to universal acceptance; but some of the same zoölogists, by the exercise of the imagination and ingenious analogical reasoning, deduce the man from the ape, while the others cannot see nor recognize any such transformation. In this way both classes present themselves to the curious world, and gather around them supporters; and, like too many cases in our courts of law, the greatest number are convinced not so much by the law or justice of the case, as by the ingenuity and special pleading of the legal advocates.

It is not my object to criticise the speculations of any one or more of the modern scientists who have carried their investigations into the world of the imagination; in fact, it could not be done in a discourse so limited in time as this, and only intended as a prologue to our present meeting. But in order to illustrate this subject of method more fully I will refer to Darwin, whose name has become synonymous with progressive development and

natural selection, which, as we had thought, died out with Lamarck fifty years ago.

In Darwin we have one of those philosophers whose great knowledge of animal and vegetable life is transcended only by his imagination. In fact, he is to be regarded more as a metaphysician with a highly-wrought imagination than as a scientist, although a man having a most wonderful knowledge of the facts of natural history.

In England and America we find scientific men of the profoundest intellects differing completely in regard to his logic, analogies and deductions; in Germany and France the same thing—in the former of these countries some speculators saying that "his theory is our starting-point" and in France many of her best scientific men not ranking the labors of Darwin with those of pure science.

Darwin takes up the law of life and runs it into progressive development. In doing this he seems to me to increase the embarrassment which surrounds us on looking into the mysteries of creation. He is not satisfied to leave the laws of life where he finds them, or to pursue their study by logical and inductive reasoning. His method of reasoning will not allow him to remain at rest; he must be moving onward in his unification of the universe. He started with the lower orders of animals, and brought them through their various stages of progressive development until he supposed he had touched the confines of man; he then seems to have recoiled, and hesitated to pass the boundary which separated man from the lower orders of animals; but he saw that all his previous logic was bad if he stopped there, so man was made from the ape (with which no one can find fault, if the descent be legitimate). This stubborn logic pushes him still farther, and he must find some connecting link with that most remarkable property of the human face called expression; so his ingenuity has given us a very curious and readable treatise on that subject. Yet still another step must be taken in this linking together man and the lower orders of animals; it is in connection with language; and before long it is not unreasonable to expect another production from that most wonderful and ingenious intellect on the connection between the language of man and the brute creation.

Let us see for a moment to what this reasoning from analogy would lead us, if applied to chemical science, which investi-

gates a great variety of compounds exhibiting most curious analogies in all their properties. Take for instance soda and potash — how identical in almost all their properties, their compounds also arraying themselves in identically the same form, defying almost all the senses to detect their difference: if they be brought into relation with other elements, they associate themselves with these elements in identically the same way. The same is true in relation to baryta and strontia, or chlorine, bromine and iodine; the last three elements even show most curious numerical relations in regard to their combining proportions. And then when we pass to the mineral kingdom, what a wonderful property is that isomorphism in the chemistry of nature's operations!

The chemist, with all these facts before him, has as much right to revel in the imaginary formation of sodium from potassium, or iodine and bromine from chlorine, by a process of development, and call it science, as the naturalist has to revel in many of his wild speculations, or the physicist who studies the stellar space to imagine it permeated by mind as well as light — mind such as has formed the poet, the statesman, or the philosopher.

Yet any chemist who would quit his method of investigation, of marking every foot of his advance by some indelible imprint, and go back to the speculations of Albertus Magnus, Roger Bacon, and other alchemists of former ages, would soon be dropped from the list of chemists and ranked with dreamers and speculators.

To prove the truth of my assertion, that this is the legitimate result of this school of philosophy, I will quote from one of its disciples, F. W. Clarke. He says: "When one is fairly started on a line of thought it is hard to come to an end. If we assume an hypothesis to be true, a hundred others rush in upon the mind and demand consideration. We do not know but that the evolution of one element from another may be possible. The demonstrated unity of force leads us by analogy to expect a similar unity of matter. Those elements which seem to-day so diverse in character may be after all one in essence; at present it can neither be discarded as false nor accepted as true."

What is most remarkable in connection with the above opinion is that the author of it is commenting on matter, in connection with the spectroscope, an instrument whose very triumphs are based on the grand distinguishing lines in the elements of matter,

whether in the earth, sun, stars, or nebulæ, all telling the same dissimilarity and no coalescence.

Is this to be one of the methods of modern science, I would ask? While in our ignorance and short-sightedness we should be careful in pronouncing any assumption as possible or impossible, still there is no reason why these terms should have much or any weight in the study of science; for in the abstract all things in nature are possible, not from any demonstration, but simply because no one can assert an impossibility. What a mass of confusion science would become if we studied its possibilities! for then every conceivable possibility would be entitled to equal consideration. And we are not therefore surprised that the author last quoted should say, "So then we may proceed to theorize in the most barefaced manner, without quitting the legitimate domain of science."

Are we to introduce into science a kind of purgatory in which to place undemonstrable speculations, and keep them there in a state of probation, and say that science cannot discard a theory as false when it cannot be accepted as true? Science, which is preëminently the pursuit of truth, has but one course to pursue: it must either accept or reject what may be thrust upon it.

What I have said is, in my humble opinion, warranted by the departure Darwin and others have made from true science in their purely speculative studies; and neither he nor any other searcher after truth expects to hazard great and startling opinions without at the same time courting and desiring criticism; yet dissension from his views in no way proves him wrong—it only shows how his ideas impress the minds of other men. And just here let me contrast the daring of Darwin with the position assumed by one of the great French naturalists of the present day, Professor Quatrefages, in a recent discourse on the physical character of the human race. In referring to the question of the first origin of man he says distinctly that in his opinion it is one that belongs not to science; these questions are treated by theologians and philosophers: "Neither here nor at the Museum am I, nor do I wish to be, either a theologian or a philosopher. I am simply a man of science; and it is in the name of comparative physiology, of botanical and zoological geography, of geology and palæontology, in the name of the laws which govern man as well as animals and plants, that I have always spoken." And studying man as a

scientist, he goes on to say: "It is established that man has two grand faculties of which we find not even a *trace* among animals. *He alone* has the moral sentiment of good and evil; *he alone* believes in a future existence succeeding this actual life; *he alone* believes in beings superior to himself, that he has never seen, and that are capable of influencing his life for good or evil; in other words, *man alone is endowed with morality and religion.*"

And it may be added that Hartmann, a philosopher of another school, says, selection explains the progress in perfection of an already existing type within its own degrees of organization, but it cannot explain the passage from an inferior degree of organization to a superior one.

If Prof. Quatrefages be right in regard to the moral sentiment in man, then Darwin must be wrong in asserting the development of man out of that in which not a trace exists of what most preëminently constitutes man; or he must satisfy himself with evolving the physical part of man out of the lower order of animals, and then by some creative force implanting within him these principles.

Our own distinguished naturalist and associate, Prof. Agassiz, reverts to this theory of evolution in the same positive manner, and with such earnestness and warmth as to call forth severe editorial criticisms, by speaking of it as a "mere mine of assertion," and of "the danger of stretching inferences from a few observations to a wide field," and he is called upon to collect "real observations to disprove the evolution hypothesis." I would here remark, in defence of my distinguished friend, that scientific investigation will assume a curious phase when its votaries are required to occupy time in looking up facts, and seriously attempting to disprove any and every hypothesis based upon proof, some of it not even rising to the dignity of circumstantial evidence.

I have dwelt longer on this one point than I had intended; but the very popular manner in which in recent years it has been presented to the public mind of all classes of society, and to persons of all ages, warranted a full notice in speaking of the importance of avoiding, as far as possible, undue speculation in connection with our method of scientific investigation.

Let me not be understood to underrate the brilliant ideas and great learning of those most distinguished men of the nineteenth

century, Darwin, Huxley and others. I am too great a respecter of both science and the pursuit of science ever to encourage by my example anything like dogmatism among scientific men. While arraying methods of study in other branches of science to combat those employed by the followers of the evolution hypothesis, I most willingly indorse what Tyndall says concerning it, viz: "I do not think the evolution hypothesis is to be flouted away contemptuously; I do not think it is to be denounced as wicked. Fear not the evolution hypothesis! it does not solve, it does not profess to solve, the ultimate mystery of the universe. It leaves in fact that mystery untouched." If it be grounded on truth, it will survive all attempts to overthrow it; if based on error, it will disappear, as many so-called scientific facts have done before. Science is a progressive study. It does not dogmatically pronounce itself as infallible; it is at all times ready to admit what has been once rejected, if it return clothed with truthful demonstration which science properly calls for as a passport to admission into its domain.

I would also caution my associates to avoid carefully what may be called the pride of modern science; for so rapid have been the discoveries of science during the last century, crowding upon us especially during the past twenty-five years, that we are apt to become bewildered and dazzled, and cry out in unbounded enthusiasm: Great is the god Science! it revealeth all things to us, and we will consecrate our talent and our time to its worship. The marvellous discoveries in chemistry, geology, electricity, light, etc., have lifted the veil that concealed from us so many of nature's secrets that we are almost baffled in our attempt to systematize them. The wonderful organic compounds; the disinterring of curious records of past ages; the obedient and submissive lightning that carries our messages; that wonderful light, so quiet in its operations, yet so powerful to reveal the chemistry of the universe; and the conservation of force — all these, I say, bewilder the mind so that we revel in building bright air-castles, almost losing our mental equilibrium. Of all scientists of the present day the chemists perhaps have kept a more stable equilibrium than any other class, starting out with a fixed law to govern them in regard to what are considered elements, never in any instance tolerating the development or transmutation of one element out of another, however remarkable the analogy they may exhibit

in the material constitution of all known substances, and recognizing them as the same whether in the earth or in the sun.

I would, therefore, caution against too great enthusiasm, for we are far more ignorant than we sometimes suppose. In fact, true philosophy dictates to its followers humility, and that it is the province of ignorance to believe that it knows everything, while the philosopher is aware that he knows little or nothing.

While we are prying into space, and studying the matter, size and movements of the heavenly bodies far beyond our own universe, we leave behind us a vast number of things that have baffled our scrutiny and defied both science and metaphysics. When we look at our bodies, without reference to the consciousness that is within, but merely studying what relates to our physical parts, how many things concerning it we have not discovered!

While occupied, the early part of this year, in reflecting upon the conservation of force and certain meteoric phenomena connected with the sun, my attention was frequently drawn to the small-pox that was then in the form of a violent epidemic around me. Seeing persons being vaccinated who had in their childhood been subjected to the same operation, and observing in the vast majority of cases the failure of the production of any effect, I asked myself the question: How are we to rank that mysterious agent which, when brought to bear upon the system, in however minute a quantity, not only permeates every fibre and cell in every part of the body, but is never lost? for when through years every particle of the body (with perhaps the exception of the teeth and a part of the bones) has been renewed over and over again, yet, as each particle gave place to a new one, this vaccine energy (if I may so call it) was imparted to the new matter, and so on through life. Here then was the conservation of a force as mysterious in its course and operation, and as hard to be understood, as that of motion, light, or any other of the recognized forms of the energies of matter.

Yes! after we have studied the heavens and all contained therein that the aided eye can reach, we shall yet have to descend to earth and study the every-day physical phenomena that are in and around men, finding even greater mysteries to unravel that meet our unaided senses every moment of our existence.

I come now to the last point to which I wish to call the attention of the members of the Association in the pursuit of their in-

vestigations, and the speculations to which these give rise in their minds.

Reference has already been made to the tendency of quitting the physical to revel in the metaphysical, which, however, is not peculiar to this age, for it belonged as well to the times of Plato and Aristotle as it does to ours. More special reference will be made here to the proclivity of the present epoch among philosophers and theologians to parade science and religion side by side; talking of reconciling science and religion, as if they had ever been unreconciled. Scientists and theologians may have quarrelled, but never science and religion. At dinners they are toasted in the same breath, and calls made on clergymen to respond, who, for fear of giving offence, or lacking the fire and firmness of St. Paul, utter a vast amount of platitudes about the beauty of science and the truth of religion, trembling in their shoes all the time, fearing that science, falsely so called, may take away their professional calling, instead of uttering in voice of thunder, like the Boanerges of the gospel, that "the world by wisdom knew not God." And it never will. Our religion is made so plain by the light of faith that the wayfaring man, though a fool, cannot err therein.

No, gentlemen; I firmly believe that there is less connection between science and religion than there is between jurisprudence and astronomy, and the sooner this is understood the better it will be for both.

Religion is based upon revelation as given to us in a book, the contents of which are never changed, and of which there have been no revised or corrected editions since it was first given, except so far as man has interpolated; a book more or less perfectly understood by mankind, but clear and unequivocal in all essential points concerning the relation of man to his Creator; a book that affords practical directions, but no theory; a book of facts, and not of arguments; a book that has been damaged more by theologians than by all the pantheists and atheists that have ever lived and turned their invectives against it—and no one source of mischief on the part of theologians is greater than that of admitting the profound mystery of many parts of it, and almost in the next breath attempting some sort of explanation of these mysteries. The book is just what Richard Whately says it is, viz.: "Not the philosophy of the human mind, nor yet the philosophy of

the divine nature in itself, but (that which is properly *religion*) the *relation* and connection of the two beings — what God is to us, what he has done and will do for us, and what we are to be in regard to him."

Now science on her part has her records: they are the discovered truths in the relation that man bears to the animate and inanimate kingdoms around him, so far as they are made out by him from time to time; but as he has to proceed in his labors with imperfect instruments and often equally imperfect senses, he has to correct himself over and over again; and his observations and theories, especially the latter, make frequent shifts, though each time he supposes that the truth has been reached. I will exemplify this in a marked manner by an extract from a recent discourse by Prof. Ferdinand Cohn, delivered before the Silesian Society for Natural Culture. In speaking of Humboldt and his Cosmos (which he styles the "Divina Commedia" of Science, embracing the whole universe in its two spheres, heaven and earth) he says: "But we cannot conceal from ourselves that the Cosmos, *published twenty-five years ago*, is in many of its parts now antiquated. Any one who to-day would attempt to recast the Cosmos must proceed like the Italian architect who took the pillars and blocks of the broken temples of antiquity, added new ones, and rebuilt the whole after a new plan." And I would simply ask: When is this new structure to be torn down to form material for another? Surely the most enthusiastic admirer of the development of the last twenty-five years does not think that we have arrived at the end of all things!

I will take yet another example. For the last fifty years or more the unity of the human race has been a most prolific subject of investigation and discussion, until it was generally conceded that there must have been more than one origin for the different races. In fact, theologians had already entered on that mischievous work called reconciling science and religion, and saying that after all there was some little mistake in the biblical record on that subject, and, if the Author would only permit, it would be well to make a correction just there; but this could not be done, and there it stood — that all men were of one flesh. But science, restless, changeful, moved on; and to-day the unity of the human race is insisted on by nearly all the leading naturalists, who teach what Prof. De Quatrefages teaches, as uttered in a recent lecture

of his. He says: "In this examination of the physical man everything leads to the conclusion which we had already reached in our earlier lecture, and *we can repeat with redoubled certainty* that the differences among human groups are characters of race, and not of species. There exists only one human species, and consequently all men are brothers; all ought to be treated as such, whatever the origin, the blood, the color, the race;" and in conclusion he further says: "I shall not regret either my time or my pains, if I am able, in the *name of science, and that alone*, to render a little more clear and precise for you the great and sacred notion of the brotherhood of man."

One other example under this head, and I have done. The book of science teaches that the sun is the source of all light and heat; yet in that post-prophetic chapter of the book of our religion it is said that the creation of the first day was light, and not until afterward was the sun created; and this was again a stumbling-block to theologians, and many wished that Moses had been a little more particular. But science in its onward march, as it grouped together the matter floating in space to form in the beginning of time this earth (our circling globe), tells us that if we can imagine one to have been placed on our globe before it had consolidated, he would have seen vast seas of vapor floating around and far above it, shutting out the very light of heaven so that darkness brooded over the waters; that the first benign influence that smiled upon the earth was the gentle rays of light struggling through the dark mist; and the prophetic eye, either on the plain, in the valley, or on the highest mountain peak, would not behold whence it came, and might exclaim in sublime poetic ecstasy: "God said, Let there be light; and there was light." Not until ages, perhaps, after that did the bright orb of the sun reveal itself to the prophet as the source of this light.

So I say, let our book of religion stand as it is; if it be not of God it will come to naught; and let science search for truth, and if it mistake its results it is certain to correct them in time, for the causes of its perturbations are as surely discovered as Leverrier and Adams discovered those of Uranus.

Science and religion are both travelling towards the same great point — the Author of all truth — yet by two very different roads; and if they be induced every now and then to turn off their

routes to compare notes, they will very much retard each other's progress and waste much time in discussing the peculiar merits of their particular road, and get into a quarrel about them. The roads they travel are paved with certain principles and forces, but of very different natures.

Science treads on certain mathematical axioms and principles, recognizing matter and certain forces or modifications of an energy innate in matter, as heat, light, electricity, etc. Religion is guided by its axioms and principles, faith, love and hope, and with these it is expected to work out its great end in the present and future of mankind. Science is nature revealed; religion is nature's God revealed; and neither the one nor the other can be without its axioms, incapable of demonstration.

Some may mock at faith and say "Faith is bankrupt, and her accounts are under strict examination, to determine what assets remain to be distributed among the impoverished souls that are her creditors;" still it is an axiom made manifest to our consciousness, as much as the axiom that a mathematical point is something without length, breadth or thickness, or that a line has length without breadth or thickness.

This faith is as much an energy of the immortal, as heat is one of the energies of matter. We know heat by its phenomena alone, and we know faith in the same way, its phenomena proving its existence as well to the child as to the man, to the learned and the unlearned. It led Socrates and Plato, even with their imperfect light, to the great God, the Creator of the heavens and the earth, and to a belief in the immortality of the soul.

What God is in his essence we know not, nor how it is that he can exist. A Being not made by himself nor any one else; without beginning of days or end of years; existing through infinite ages; filling immensity without being in any place; everywhere present without displacing a single one of his myriad creatures; pervading all things yet without motion; being all eye, all ear, all energy, and yet not interfering in the least with the thoughts and actions of man;—this has been well styled "the greatest mystery of the universe, enveloped at once in a flood of light and an abyss of darkness—inexplicable itself, explaining everything else, and after displacing every other difficulty, itself remaining in inapproachable, insurmountable, incomprehensible

grandeur, so that the Psalmist exclaims: 'Clouds and darkness are round about him; righteousness and judgment are the habitation of his throne.'"

This is the God whose existence reason cannot prove, while it cannot disprove, and for whom the religionists and scientists are looking: that they will one day see him as he is, is my firm belief, and, as I before stated, they will see him the sooner by keeping separate roads.

That many a scientist will be swallowed up in pantheism from want of patience is to be expected, and, I regret to acknowledge, will with Hartmann "maintain that creation is a cause, existence a misfortune, life a deepening disappointment, and that the extinction of personal consciousness is the only salvation;" but many more will enjoy the double felicity of arriving at the great end sustained both by science and by religion, and will agree with what Socrates wrote nearly two thousand years ago, without the revealed word of God to enlighten him—or to mystify him, as some would say. Listen to that philosopher of ancient days as he says: "This great God, who has formed the universe and supported the stupendous work whose every part is finished with the utmost goodness and harmony—he who preserves them perpetually in immortal vigor, and causes them to obey him with a never-failing punctuality and a rapidity not to be followed by the imagination—this God makes himself sufficiently visible by the endless wonders of which he is the author, but continues always invisible in himself. Let us not then refuse to believe even what we do not see, and let us supply the defects of our corporeal eyes by using those of the soul; but let us learn to render the just homage of respect and veneration to the divinity whose will it seems to be that we should have no other perception of him than by his benefits vouchsafed to us."

I cannot close this part of my subject without reverting to the tendency of certain men of science to make physical experiment the test of all truth; even prayer and divine providence influencing affairs in this world must become subjects for experiment; and if the results be not in accordance with the experiments, then suspicion is to be cast on faith. This has been truly explained as coming from the spirit of an age which strives to make natural science the all in all of wisdom, and begins with nature in-

stead of beginning with God, and ends with burying man and even God within physical conditions, and assigning to the supreme Spirit the impersonality that is usually ascribed to material nature; and all this in spite of the fact that profound philosophers and earnest devotees have believed in the existence of a consciousness subject to influence above their sense.

If we look at nature as science has thus far penetrated into her mysteries, we discover in the innermost parts of the earth matter in a constantly restless state; in the ocean or the air we behold the ever moving, never resting; above are the sun and stars speeding on through boundless space, and they in their own masses are like huge boiling caldrons casting their vapors hundreds of thousands of miles into space. And so the toiler in science goes penetrating nearer and nearer, as he thinks, to the great cause of all things. In the same way he thinks he has discovered the cause of all motion upon this planet, both in the animate and inanimate, and he hastily concludes that the energy resident in the sun is fixed and invariable; yet while he reasons as if he had arrived at the prime cause, he admits that there is something yet unknown on which the sun depends as much as the earth does upon the sun.

While I admit most freely that the smallest event in the physical world is but the sequence of secondary causes (if I may use the expression) and effects, obedient to what appear to us fixed and invariable laws, yet it is illogical for any mind to assert that they cannot be altered by the operation of some energy that may reach beyond any cause yet discovered by the light of science.

While the *energy of the sun* travels in swift motion and in rapid undulations through the ethereal space that divides the earth from the sun, and in turn science by the spectroscope travels back from the earth to the sun over the same waves, and has revealed to her, in writing as it were, on the beautiful pages of the spectrum, the composition of that incandescent globe and the mighty power of its internal forces, so does the *energy of that great cause* that formed the sun reveal itself to the internal consciousness, reaching the eye of faith, by undulations more rapid than light; and as faith travels back, looking through its spectroscope (the revealed word of God), it beholds the constitution of that great cause as composed of infinite love and mercy, truth and justice.

As light has revealed the sun to us by penetrating an organ specially formed for its impressions, *the physical eye*, so is God revealed by faith, *the soul's eye*. As well might we say that we are acquainted with all phenomena of the rays of the sun as to arrogate to ourselves the power of limiting the operations of faith.

In these things science is both vain and modest, logical and illogical; as, for example, here is what Dr. Cohn says, in a discourse of his previously referred to: "The deeper natural science penetrates from outward phenomena to universal laws, the more she lays aside her former fear to test the latest fundamental laws of being and becoming, of space and time, of life and spirit:" and in the next breath he says: "It is not to be hoped that during the next twenty-five years all the questions of science which are at present being agitated will be solved. As one veil after another is lifted *we find ourselves behind a still thicker one*, which conceals from our longing eyes the mysterious goddess of whom we are in search."

How Dr. Cohn expects to justify his first statement by his last assertion of the increasing thickness of the impenetrable veil is more than my logic can divine.

But in this matter of subjecting faith to physical test by what is now commonly called the "prayer-gauge," philosophers of the most advanced school differ very widely in their opinion; and that remarkable pantheist (or pessimist), Edward Von Hartmann (probably the most remarkable man of that school since the days of Spinosa, who believing only in nature, yet ranks with the old patriarchs in his idea of the power of faith, or something next akin to it) calls all mankind to "combine together in one grand act of self-abdication, and to resign the very faculty of will by a mighty concert, not of prayer, but of self-renunciation—by the help of such means as art and science may apply, and by such perfection of the magnetic telegraph as shall enable them all at once to will not to will any more, and so to bring all conscious personal life to an end by an absorption in the almighty and unconscious spirit." Not the most ascetic religious devotee could exhibit more unbounded confidence in the power of faith subverting not only the laws of nature, but nature herself, than is expressed in those views.

In fine then, gentlemen, let us stick to science—pure, unadulter-

ated science—and leave to religion things which pertain to it; for science and religion are like two mighty rivers flowing toward the same ocean, and before reaching it they will meet and mingle their pure streams, and flow together into that vast ocean of truth which encircles the throne of the great Author of all truth, whether pertaining to science or religion.

I will here, in defence of science, assert that there is a greater proportion of its votaries who revere and honor religion in its broadest sense, as understood by the Christian world, than in any other of the learned secular pursuits.

In this address I may be accused of more or less dogmatism: but I can assure the Association that whatever there may be of apparent dogmatism arises entirely from my reluctance to consume more time in making explanations and reasoning fully on the topics discussed. I have moreover departed from the usual character of discourses delivered by the retiring presidents of this Association, and have not presented a topic that might have been of more interest to you, viz., some special scientific subject coming more immediately within the province of my research: for this departure I claim your indulgence, as well as for omitting all allusion to scientific progress during the past year.

But before concluding I cannot refrain from referring to one great event in the history of American science during the past year, as it will doubtless mark an epoch in the development of science in this country. I refer to the noble gift of a noble foreigner to encourage the poor but worthy student of pure science in this country.

It is needless for me to insist on the estimation in which Prof. John Tyndall is held amongst us. We know him to be a man whose heart is as large as his head, both contributing to the cause of science. We regard him as one of the ablest physicists of the time, and one of the most *level-headed* philosophers that England has ever produced—a man whose intellect is as symmetrical as the circle, with its every point equidistant from the centre.

We have been the recipients of former endowments from that land which, we thank God, is our mother country, from which we have drawn our language, our liberty, our laws, our literature, our science, and our energy, and without whose wealth our material development would not be what it is at the present day. Count Rumford, the founder of the Royal Society of London, in

earlier years endowed a scientific chair in one of our larger universities, and Smithson transferred his fortune to our shores to promote the diffusion of science.

Now, while these are noble gifts, yet Count Rumford was giving to his own countrymen—for he was an American—and both his and Smithson's were posthumous gifts from men of large fortune.

But the one to which I now refer was from a man who ranks not with the wealthy, and he laid his offering upon the altar of science in this country with his own hands; and it has been both consecrated and blest by noble words from his own lips; all of which makes the gift a rich treasure to American science; and I think we can assure him that as the same Anglo Saxon blood flows in our veins as does in his (tempered, it is true, with the Celtic, Teutonic, Latin, etc.), he may expect much from the American student in pure science as the offspring of his gift and his example.

With this feeble tribute to our distinguished scientific collaborator I bid you adieu, and, returning to the Association my most heartfelt thanks for the honor that has been conferred on me, surrender the mantle of my office to one most worthy to wear it—Professor Lovering, of Cambridge.

PAPERS READ

AT THE

PORTLAND MEETING.

A. MATHEMATICS, PHYSICS AND CHEMISTRY.

NOTE ON DR. WILLIAM WATSON'S COÖRDINATES IN A PLANE. By THOMAS HILL, of Portland, Maine.

AT the meeting of this Association in August, 1859, Dr. William Watson proposed to take, as coördinates in a plane, q, the length of a perpendicular let fall from the origin upon the normal, and ν the angle which this perpendicular makes with a fixed axis. He showed that from this system, we readily pass to Peirce's coördinates, by the formula

$$\rho = D_\nu q + \textstyle\int_\nu q.$$

Thus the equation $q = A \cos a\,\nu$ gives $\rho = \left(\frac{1-a^2}{a}\right) A \sin a\,\nu + c;$

which is evidently, when $c = o$, the equation of an epicycloid, A being the radius of the stationary, and $A\ \left(\frac{1-a}{2a}\right)$ that of the rolling circle. The epicycloid becomes a point before transformation into a hypocycloid as the value of a is made to pass through $\pm$ 1. Thus any point in the plane, or any circle about that point, can be represented by the equation

$$q = A \cos (\nu_0 - \nu).$$

The values $+a$ and $-a$ give identical forms to the curve, but a different genesis, by the familiar laws of these curves.

I propose a slight modification of Dr. Watson's system, by taking p, the length of the perpendicular let fall from the origin upon the tangent, and using ν to express the angle made by this

perpendicular with a fixed axis. Assuming then $p=f(\nu)$ we have $q=D_\nu p=p'$ (that is p of the evolute), and $\rho=p+D_\nu^2 p$ (radius of curvature), $r=\sqrt{p^2+(D_\nu p)^2}$ (radius vector).

If we wish to transform to a new origin at the distance b and direction θ, it is evident that

$$\underset{b}{p}=p-b\cos(\theta-\nu)$$

and if we wish then to rotate the axis through the angle a we must substitute

$$\nu=\nu_1+a\,.$$

The curve can be constructed by points, either by setting off p in the direction ν and erecting $D_\nu p$ perpendicular to it, or by the equations for transforming to the Cartesian system,

$$x=p\cos\nu-Dp\sin\nu$$
$$y=p\sin\nu+Dp\cos\nu.$$

Either mode can be checked by calculating r.

Problem I. To investigate the equation.

(1) $$p=A\,(\sin a\,\nu)^n.$$

By the formula already given we obtain

(2) $$\rho=A\,\big((a^2(n^2-n))(\sin a\,\nu)^{n-2}+(1-a^2 n^2)(\sin a\,\nu)^n\big).$$

When $n=1$, or $p=A\sin a\,\nu$, this reduces to

(3) $\rho=(1-a^2)\,A\sin a\,\nu\;=(1-a^2)\,p$, which is an epicycloid.

For $n=\frac{1}{a}$ equation (2) reduces to

(4) $$\rho=(a-1)\,A\,(\sin a\,\nu)^{\frac{1-2a}{a}}.$$

This gives for $a=\frac{1}{2}$, $p=A\,(\sin\frac{1}{2}\,\nu)^2$, $\rho=\frac{1}{2}A$, a circle. And for $a=\frac{1}{3}$, $p=A\,(\sin\frac{1}{3}\,\nu)^3$, $\rho=\frac{2}{3}A\sin\frac{1}{3}\,\nu$ which is an epicycloid, the cardioid, referred to its cusp as origin, while by (3) it is referred to the centre of the stationary circle.

For the case of (3), $p=A\sin a\,\nu$, we have

(5) $$r=A\,(a^2+(1-a^2)(\sin a\,\nu)^2)^{\frac{1}{2}}.$$

When in this case $a=1$, we get $\rho=0$, $r=\pm A$, which is a point at the distance A from the origin, the direction being shown by the formula for transformation to be $\theta=(n+\frac{1}{2})\,\pi$.

For the case $n=\frac{1}{a}$ as in (4), we have

(6) $$r=A\,(\sin a\,\nu)^{\frac{1-a}{a}}$$

which again reduces to $\rho = A$ for $a = 1$ and to $r = A \sin \frac{1}{2} \nu$ for the first case under (4), showing that the axis is a diameter of that circle, and that the origin is at the right-hand intersection with the circumference.

If in equation (2) we put $n = -1$ and $a = 1$ we obtain

$$(7) \qquad \rho = 2\, A\, (cosec\, \nu)^3$$

which shows that $p = A\ cosec\ \nu$ is the equation of a parabola, while the radius vector becomes $r = A\ (cosec\ \nu)^2$, showing that p has other remarkable properties than those which I pointed out in "Gould's Astron. Journal," vol. ii, p. 10, 11, since it bisects the angle between the radius vector and the axis. It will also be observed that a perpendicular raised from the focus of a parabola upon the radius vector bisects the radius of curvature, by (7).

When we make $a = 1$ and $n = 2$, equation (2) gives for $p = A\, (\sin \nu)^2$, $\rho = -3\, A\, (\sin \nu)^2$ which is one of the involutes of a hypocycloid of four cusps.

Problem II. To find the equation of a cycloid, and reduce it to its simplest form.

When in equation (3) representing an epicycloid we attempt to make the stationary circle infinite we find the equation rendered worthless; $a = \frac{R}{R+2r'}$, becomes unity, but $A = R + 2r'$ becomes infinite. We therefore, directly from the geometry of the cycloid, taking our origin at the middle of the chord joining two cusps, find

$$p = r'\ (2 \sin \nu + (\pi - 2\,\nu) \cos \nu).$$

Taking a new origin at the vertex of the arch gives

$$p = r'\ (\pi - 2\,\nu) \cos \nu.$$

Rotating the axis through a right angle reduces this to

$$p = 2\, r'\, \nu \sin \nu,$$

which is the simplest form of the equation of a cycloid, r' being the radius of the generating circle and ν the angle made by p with a normal at the vertex.

Problem III. To transform the case of equation (4) to polar coördinates; the case when $na = 1$.

The equation of the curve being written $p = A \left(\sin \frac{\nu}{n}\right)^n$ we find $r = A \left(\sin \frac{\nu}{n}\right)^{n-1.}$ But (since in every curve, $p = r \sin \varepsilon$) this shows that ε is here equal to $\frac{\nu}{n}$. And since in every curve the

polar angle, Φ, must be the sum of ν in its present sense, plus the complement of ϵ, we have in this curve

$$\Phi = \nu + \frac{\pi}{2} - \frac{\nu}{n}$$

which by reduction gives

$$\frac{\nu}{n} = \frac{\frac{1}{2}\pi - \phi}{1-n}.$$

Rotating now the polar axis through a right angle, and thus eliminating $\frac{1}{2}\pi$ from the second member, we get by substitution

$$r = A\left(\sin\frac{\phi}{1-n}\right)^{n-1}$$

as the polar equation of the curve, which may evidently be written in the form

$$r = A\left(\sin\frac{\phi}{m}\right)^{m}$$

in the same form as p, and the value of p in terms of Φ becomes,

$$p = A\left(\sin\frac{\phi}{m}\right)^{m+1.}$$

Problem IV. The logarithmic spiral $p = A^{\nu}$ apparently presents no difficulties.

Problem V. The equation, $p = A\nu^{n}$, n being a positive integer, gives the involutes of a circle.

Problem VI. The equation $p = A\,\nu^{2} \sin \nu$, gives for the radius of curvature

$$\rho = 2\,A\,(\sin \nu + 2 \cos \nu).$$

This curve evidently enjoys the property of repeating itself in its evolutes; its arches are all tangent to a straight line through the origin, perpendicular to the axis, at its cusps the tangent of $\nu = -2$, and the cusps are all situated on a parabola with its axis lying in the same direction.

A NEW CURVE. By THOMAS HILL, of Portland, Me.

THE equation $\rho = Ay$ represents a curve, that in outward appearance resembles that case of the elastic curve in which it does not cross the axis. By integration we obtain

$$\rho = e^{A \sin \nu + B};\ \text{or}\ \log \rho = A \sin \nu + B$$

In this equation, B only affects the scale of magnitude. A change of sign in A simply throws the curve below the axis.

For $A=0$ the curve becomes a circle infinitely removed from the axis. For $A=\infty$ the curve is a straight line, falling perpendicularly on the axis but not crossing it. If however this case be drawn on an infinite scale by making B also ∞, the value $\sin \nu = -1$ may make ρ finite; that is, we see only the bottom of the loop tangent to the axis. But draw it on an infinitesimal scale by making $B=-\infty$, and the value $\sin \nu = 1$ may make ρ finite, showing us the top of an arch coinciding with the axis.

The value of the ordinate at the top of the arch is $y_1 = \frac{1}{A} e^{A}$ and for the bottom of a loop is $y_2 = \frac{1}{A e^{A}}$

FOUR EQUATIONS PARTIALLY DISCUSSED. By THOMAS HILL, of Portland, Me.

1. In the "Proceedings" of this Association, vols. xi, p. 42; xii, pp. 1-6; and xiii, p. 158, will be found preliminary discussions of some systems of coördinates, in which the present equations are further examples.

2. Let the radius of curvature be proportionate to some power of the ordinate, *i. e.*,

$$\rho = A y^n.$$

The geometry of the differentials gives, if τ, the angle of the curve with the axis, is taken as the variable,

$$\rho\, d\tau = A y^n\, d\tau = dy \cos \tau.$$

3. Whence by integration

$$y = \left((n-1)(A \cos \tau - B)\right)^{\frac{1}{1-n}}$$

$$\rho = A\left((n-1)(A \cos \tau - B)\right)^{\frac{n}{1-n}}.$$

4. These equations show that $\rho = A y^n$ represents, when
   $n=-1$, the elastic curve,
   $n=\frac{1}{2}$, the cycloid and its involutes,
   $n=\frac{2}{3}$, an oval involute to a 4-cusped hypocycloid,

$n=1$, a curve presented in a separate paper at this meeting,
$n=\frac{3}{2}$, a curve which for $B=0$ becomes a parabola,
$n=2$, a curve which for $B=0$ becomes the catenary.

5. The ratio of ρ to y may be written

$$\frac{\rho}{y}=\frac{A}{(n-1)(A\cos\tau-B)}$$

which for the special case $B=0$ gives

$$y=(n-1)\,\rho\cos\tau\ =(n-1)\,\rho\sin\tau$$

$$\rho=\left(A^n\,(n-1)\right)^{\frac{n}{1-n}}(\sin\tau)^{\frac{n}{1-n}}$$

I had discussed this last equation, and its caustics, (Gould's Ast. Jour., ii, 84), before perceiving that it includes that case of the elastic curve in which it crosses the axis at right angles.

6. Let the radius of curvature be proportional to the nth power of the radius vector. This gives us

$$\rho=Ar^n \qquad p=\int_r\frac{r}{\rho}$$

$$p=B-\frac{1}{(n-2)\,Ar^{n-2}}.$$

And for all cases in which B is put $=0$

$$\varepsilon=(1-n)\,\Phi+C;\ \tau=(2-n)\,\Phi+C.$$

7. If, in §6, $n=-1$, we find that for negative values of B the curve is a series of loops, no one of which encloses the origin; for positive values of B, less than $\frac{2}{3}\sqrt{A}$, a series of loops, each enclosing the origin; and for $B=0$, four loops meeting in the origin. In the last case, the curve may be transformed, with a loss of the alternate loops, into the forms:

$$r=\sqrt{3\,A\,\sin 2\,\Phi}\ =\sqrt{3\,A\,\sin\varepsilon}\,;\ \tau=3\,\Phi.$$

For the value of $B=\frac{2}{3}\sqrt{A}$ this curve is a circle, with the radius $\sqrt{A}$.

8. When n is put $=1$, and $B=0$, we obtain

$$\log r=\Phi\sqrt{A^2-1}$$

which is the equation of a logarithmic spiral. Inasmuch as in every curve the radius of the evolute may be written

$$\rho'=D_p\rho\,(r^2-p^2)^{\frac{1}{2}}$$

and its radius vector

$$r' = \sqrt{r^2 + \rho^2 - 2\rho p}$$

we easily show that, in the case of this article, we have

$$\rho' = A r'$$

which is a new demonstration of a familiar property of the spira mirabilis.

9. For $n = 1$, when B is negative, the curve, examined by the lemma

$$D_{\phi}\,\varepsilon = \frac{r^2}{\rho p} - 1$$

will be found to be a double spiraloid, enclosing the origin in a

CORRIGENDA.

The reader is requested to make the following corrections with a pen; Vol. xix, p. 21, the last line should be written,

$$\rho_n = \mathrm{R}\frac{(n + \mu)^n}{n\,!} = \mathrm{R}\,\frac{n^n}{n\,!}\,e^{\mu} = \mathrm{R}e^{\mu + n}\,;$$

and the close of the first line on p. 22 should be written,

$$\rho_n = \mathrm{R}e^{\mu} = e\mathrm{S}_n = \mathrm{R}e^{e\varphi}.$$

$$\frac{2\sqrt{1+m}}{2+m}.$$

12. Making $n = \frac{3}{2}$, we have for $B = 0$

$$\varepsilon = C - \tfrac{1}{2}\,\Phi\,; \quad \tau = C + \tfrac{1}{2}\,\Phi$$

which are evident equations of a parabola.

13. Making $n=2$, we have for $B=0$

$$\varepsilon=-\Phi;\ \tau=C;\ p=-\infty$$

so that the curve has become a straight line at an infinite distance, parallel to the axis.

14. Making $n=3$, we obtain $\varepsilon=-2\,\Phi$; $\tau=-\Phi$ showing the curve to be an equilateral hyperbola.

15. Thus a rapid preliminary survey of the equation $\rho=Ar^n$ shows it to contain circles, log. spirals, involutes of circles, and of epicycloids, parabolas, hyperbolas, and many interesting new curves.

16. Let us now suppose the radius of curvature to be proportional to the nth power of the length of a perpendicular let fall from the origin upon the tangent; $\rho=Ap^n$.

17. In this case we readily obtain

$$r^2+B=\frac{2A}{n+1}\,p^{\,n+1};\ r=\sqrt{\frac{2A}{n+1}\,p^{\,n+1}-B}$$

$$\rho=\frac{\left((n+1)\,(r^2+B)\right)^{\frac{n}{n+1}}}{2\,A^{\frac{1}{n+1}}}$$

18. This equation shows that by putting $n'=\frac{2n}{n+1}$ we shall obtain, for $B=0$, $\rho=A'r^{n'}$; so that the equation $\rho=Ap^n$ includes the curves of $\rho=Ar^n$

19. For the case $n=1$ we have $\tau=\int p\,\frac{1}{\sqrt{(A-1)\,p^2-B}}$; for values of $A>1$ this gives us

$$\tau=\frac{1}{\sqrt{A-1}}\,log\,\sqrt{Ar^2-B}+C$$

and this runs when $B\mp 0$ into a logarithmic spiral.

20. But when $A<1$, $\tau=\frac{1}{\sqrt{A-1}}\,cos^{[-1]}\sqrt{\frac{1-A}{B}}\cdot p$

whence $\rho=\sqrt{\frac{AB}{1-A}}\,cos\,\sqrt{1-A}\cdot\tau$ which is an epicycloid.

21. And when $A=1$, n being $=1$, we have $p=\sqrt{r^2+B}$, so that $q=\sqrt{-B}$, which gives us when B is negative, the involute of a circle with a radius of $\sqrt{-B}$.

22. When $n=3$, the curve reduces for $B=0$ to a parabola and for $B=-\frac{1}{2A}$, to $\rho=\sqrt{A}\cdot Cot\ \frac{\tau}{\sqrt{2}}$.

23. When $n=-3$, and $B=0$, we have $r=-\frac{A}{p}$, and the curve is the equilateral hyperbola.

24. Let us now consider the radius of curvature as proportional to the nth power of the length of the arc. This is readily integrated, and gives

$$\rho=A^{\frac{1}{1-n}}\left((1-n)\nu\right)^{\frac{n}{1-n}}.$$

When $\frac{n}{1-n}$ is a positive integer this is manifestly some involute of a circle; also for $n=1$, we have the spira mirabilis, and $n=0$, of course gives the circle. When $n=-1$ the curve starts from the origin in opposite directions and coils itself around two poles on a line passing through the origin at 45° with the axis. The distance of the poles from the origin is $\pm A\sqrt{2\pi}$.

On the Relation of Internal Fluidity to the Precession of the Equinoxes. By J. G. Barnard, U. S. Army.

Since the investigations by Sir Wm. Thomson concerning the relations between rigidity of the earth's substance and precession (see "Rigidity of the Earth," Phil. Trans., 1863), and his enunciation that "if the earth had no greater rigidity than steel or iron, it would yield about two-fifths as much to tide-producing influences as if it had no rigidity, more than three-fourths as much as if its rigidity did not exceed that of glass," and, as a consequence of the centrifugal force of diurnal rotation of these solid tidal protuberances, the precession-producing couple will be diminished in the ratio of their height to that of the tide of a wholly fluid spheroid; the question of internal fluidity has, in its relations to precession, lost much of its importance. For though, in another place, (Treatise on Nat. Philos., §848) he states that "it is interesting to remark that the popular geological hypothesis of a thin shell of solid material, having a hollow space within it filled with liquid, involves two effects of deviation from perfect rigidity which would

influence in opposite ways the amount of precession. The comparatively easy yielding of the shell must render the effective moving couple due to sun and moon much smaller than it would be if the whole interior were solid, and, on this account, must tend to diminish the amount of precession and nutation:" and he thinks that the "effective moment of inertia of a thin solid shell containing fluid in its interior would be much less than that of the whole mass if solid throughout," and hence there would be a "*compensatory* effect." But, on the other hand, he considers the probability very small that this compensation should chance to be so perfect as the actual observed precession would require it to be; and I, for my own part, believe he is in error in his notion that there is any such compensation whatever. (See note to p. 48, Smithsonian Contributions 240, "Problems of Rotary Motion.")

Nevertheless, the effect of Internal Fluidity has been made the subject of one of the most famous investigations, concerning the physics of the earth, by the late Prof. W. Hopkins* (Phil. Trans., 1839–40–42) and his results have been considered so far authoritative as to be at least referred to by most writers since. So recently as 1868 the eminent French astronomer, the late M. Delaunay, believed them entitled to a formal refutation at his hands, and another prominent writer on the "Figure of the Earth," the late Archdeacon Pratt, in his fourth edition of 1870, has attempted a "vindication of Mr. Hopkins' method" against the strictures of the French astronomer. Although neither the "refutation" nor the "vindication" is, in my opinion, either one or the other (*vide* notes pp. 39 and 49, Smithsonian Contributions, 240), the fact that, at so recent dates, they have been made, shows that the question has not wholly lost its interest; that the overshadowing influence of the question of "Rigidity" is not appreciated; or finally, perhaps I might add, that there is a large class of minds, whose opinions deservedly command respect, who will not give full credit to the results of purely mathematical investigations on such subjects.

To the latter class, the mathematician can only present *his* view of the case, and while admitting, where data are so recondite and his instrument of so feeble a grasp upon the complicated oper-

*Even Sir Wm. Thomson has quite recently ("Nature," Feb. 1, 1872) given an elaborate refutation of M. Delaunay's views of "viscosity" as an agent to nullify Prof. Hopkins' results.

ation of nature's forces, that *his* exposition may not comprehend the whole matter, claim that *his* results be arrayed against the conclusions of other investigators according to their *probable weight.*

In a paper on the "Precession of the Equinoxes in Relation to the Earth's Internal Structure," which has been read before the Academy of Sciences, and printed as "Smithsonian Contributions to Knowledge, No. 240," I have endeavored to show that the need of high *rigidity* (as first announced by Sir Wm. Thomson), to great depths, is unquestionable; that to such depths, at least, it puts *out of court* (if I may use the expression) the plea for internal fluidity; that the supposed compensation in loss of "effective moment of inertia" which even Sir Wm. Thomson would concede to fluidity has no basis of reality. If the terrestrial spheroid were wholly of fluid and (of course) wholly destitute of rigidity, the tidal protuberances developed by solar or lunar attraction can be mathematically expressed with almost perfect accuracy; and I have analytically demonstrated that the centrifugal force (due to the diurnal rotation) of the matter constituting these tidal protuberances exactly neutralizes the precession-producing couple developed by the foreign attraction, and that, in such a spheroid, there will be no precession. On the other hand, supposing the spheroid to be solid throughout, Sir Wm. Thomson has determined the degree of rigidity which its substance must possess in order that the observed precession should coincide so nearly with that which theory assigns to a perfectly rigid spheroid of its shape and laws of internal density, with this result, viz: "that the actual rigidity should be several times as great as the actual rigidity of iron throughout two thousand or more miles thickness of crust."

If *such* a degree of rigidity be needed to a crust "two thousand or more miles" thick, it is plain enough that the *thin* crust of the geologists (*i. e.*, a crust of thirty or forty-miles thickness) would demand a rigidity not only surpassing immensurably anything actually belonging to cognizable portions of the earth's external substance (and if we conceive volcanic lavas to come from the internal fluid, our cognizance extends *through* the solid crust) but surpassing anything we can reasonably attribute to solid terrestrial matter.

Very strangely, however, the idea of the precession-neutralizing effect of elastic yielding of the earth's substance does not appear

to have entered into the minds of physicists until it was announced by Prof. Thomson; or rather, I should say, it was *taken for granted* that the solid earth, or even a thin crust of solid earth, was rigid enough to be regarded, in the treatment of the problem, as *perfectly rigid.* So Prof. Hopkins, in his famous investigations, treats the problem, and he has endeavored to find in the precession of the equinoxes a *test* of the existence of internal fluidity, under this point of view. His result is probably well known to those who have given attention to this particular subject. It is, that, constituted internally in accordance with the most probable laws of density and of ellipticity of strata of equal density, there must be a solid crust of *at least* eight hundred or one thousand miles of thickness. But this determination is based upon a supposed discrepancy of one-eighth of the calculated precession between that which is observed and that due to a homogeneous spheroid having the earth's figure; a discrepancy mainly depending upon the assumption of $\frac{1}{70}$ for the moon's mass. The moon's mass is now believed to be much less, and (see Thompson and Tait, Nat. Phil., §828) the discrepancy is really, if not inappreciable, certainly small, and at any rate so indeterminate as to afford no datum for such a determination. Did such a discrepancy exist and if it were with certainty determinable, it would prove (as the subject is now understood) *not* a determinate minimum thickness of crust, *but*, that, by elastic yielding of the earth's substance, a part of the precession was lost.

It is a matter of scientific curiosity, if nothing more, to know the actual effect of internal fluidity when this yielding is *excluded* and the crust treated as perfectly rigid (for the results will have an applicability to a certain extent in the case in which the shell is supposed to yield *partially* to foreign attraction). In Prof. Hopkins' investigation, while there is an elegance of treatment and a mastery of higher analysis, combined with skill in its application to physical problems, which claim admiration, there is, at the same time, I think, a fallacy in his application to the heterogeneous spheroid, which, considering the notoriety of the investigation and the acceptance it has met with, renders it one of the "curiosities" of modern mathematics.

In the "Addendum" to the Smithsonian publication already alluded to, I have pointed out what I believe to be the underlying errors of Prof. Hopkins' analysis, and have endeavored to show

that, attributing perfect rigidity to the *shell*, and identity, in the two cases, in the law of internal density, the effect of fluidity of *nucleus* is almost absolutely *nil;* or, in other words, that the precession will be, with inappreciable difference, the same for the two cases. I shall endeavor to make this result intelligible and the effects of fluidity understood without resort to other symbolism than that of ordinary language.

In the first place, stability of the "Figure of the Earth" demands that if there be an internal fluid, it shall be possessed of the earth's diurnal rotation about an axis coincident (on the whole) with that of the shell. Hence, by some means, the fluid as a mass must be possessed of the same precessional motion as its shell. And again, supposing the earth to have been once wholly fluid, the solidification of the shell must have been governed by the law of density combined with that of temperature, and hence in speaking of a shell or crust, we speak of one having an inner surface concentric and co-axial with the outer, but with an ellipticity which may slightly vary. The questions then present themselves: "Will such an internal fluid spheroid take up a *common* precession with the shell?" And if so, "Will that common precession be the same, or not the same, as that which would belong to the entire mass solidified?"

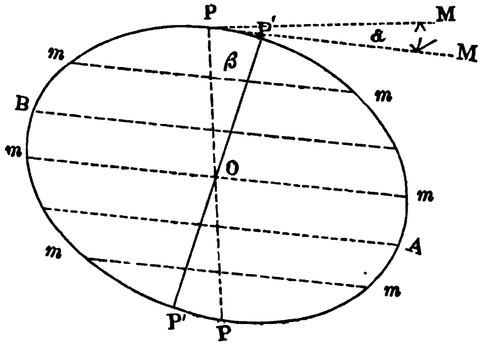
The first question Prof. Hopkins answers affirmatively; the second he answers thus:—"The same, if the *shell and fluid be homogeneous* and of same external ellipticities; *not* the same, if both the shell and fluid be heterogeneous, the fluid strata of equal density being disposed in accordance with the requirements of *equilibrium of figure.*

I answer the latter question, "The same in both cases."

To make myself understood, I must attempt to explain the internal actions and reactions of the fluid.

First: suppose the fluid *homogeneous.* Let the following figure (an ellipse of *small* ellipticity ϵ) be a meridional section of the inner surface of the shell (for it matters not how far removed the concentric external surface be). Let it be supposed, however, that the axis of the shell has been displaced, by rotation around an equatorial axis through O, normal to the plane of the figure, through a minute angle P′ O P $= \beta$ from a position P P of coincidence with that of the fluid; now through whatever causes (not acting on the fluid) the *shell* has undergone this displacement, it is

evident that the fluid will not have been at once moved *bodily* with the shell, but will have undergone the least possible change con-



sistent with the change of position of its envelope. The fluid *was* revolving in planes normal to PP; and by the changed position of the shell, portions of the fluid contiguous to the poles PP must change their planes of rotation which *were* perpendicular to PP, through the minute angle, α, to parallelism to a plane tangent at P to the displaced shell, which angle is of the same order of magnitude *with respect to* β (or POP′) as the ellipticity, ϵ, supposed small, is to ordinary magnitude (calculation gives $\alpha = 2\,\epsilon)\,\beta$; and hence a minute quantity of the second order. The least change possible in the fluid is that *all* its planes, *mm*, *mm*, *mm*, etc., come into parallelism with the tangent plane PM. In this position the rotary planes of the fluid are *skew* to their own axis; and the pressure upon the shell arising from its centrifugal forces is unsymmetrically distributed on the inner shell surface, giving rise to a "couple" acting to turn the shell back from its displaced to its original position; or on the other hand, by reaction, tending to turn the fluid mass in the reverse direction to a position of axial coincidence with the displaced shell. Since the displacement, α, of the plane of rotation is minute compared to the axial divergence POP′, this *latter* movement will be *nearly* equivalent to a rotation of the fluid *as a mass* about the equatorial axis through O; that is to say, that the forces acting on each particle to turn the fluid mass to axial coincidence with the shell, will be proportional *to its distance* from the axis through O.

This is very elegantly demonstrated by Prof. Hopkins, by reference to the conditional equations for fluid equilibrium for an enveloped fluid, by which he computes the intensity of effort for each particle. The correctness of this *rationale*, and the accuracy of his computation find (as I have elsewhere demonstrated) a very interesting confirmation in the analytical theory of the tides. The analytical expression for the tidal distortion of a revolving sphe-

roid, entirely fluid, indicates a simple displacement of the *external* configuration, like that of the diagram, the axis of the *figure* being displaced from P to P′. No attempt has been heretofore made to show *how* the fluid mass, presuming its rotary velocity and axis unchanged, adapts itself to *this* change; but I have shown (note, p. 43, Smithsonian Contributions, 240) that Prof. Hopkins' computed reaction, due to the minute change of rotary planes, is exactly equivalent to the foreign attraction-couple which would produce it; and hence we may regard tidal distortion as a minute angular displacement of the planes of rotation.

Now, in the theory of *precession*, as it is usually set forth, and as the fact is visibly exhibited by the gyroscope, rotating bodies subjected to the action of a *couple*, take a gyratory movement, the axis of rotation moving at right angles to the plane of the couple. Thus, by the interaction I have described between shell and fluid, their masses will be subjected to gyratory motion, in opposite directions, the degree of which will evidently be in inverse proportion to their respective moments of inertia (taking that of the fluid as if solid) and their gyration cannot produce greater divergence of the axis than the original disturbance, but are simply relative oscillations.*

Let us now take another view of the subject and suppose the shell and fluid both revolving with common angular velocity about their common axis of figure, to be subjected to a foreign attraction from some point (*e. g.*, the solar or lunar centres) situated at a finite distance and not in the plane of the equator. Owing to inequality of distances the resultant of this attraction, were the *whole mass* rigid, would develop a couple tending to turn (or tilt) it; and hence, as is well known, arise the phenomena of precession. But the internal *fluid* spheroid of our hypothesis is destitute of rigidity, and the shell alone will be *directly* subjected to the tilting effect and resulting precessional motion. But by the unequal action of the attraction upon the particles of the fluid, pressure will be developed upon the inner surface of the shell. If the fluid be homogeneous the analytical expression for this pressure can be directly deduced from that for the tides of a wholly fluid spheroid, as I have obtained them (Smithsonian Contribu-

* The foregoing *rationale* has reference to Prof. Hopkins' treatment. A more simple one is to regard the tilting of each fluid rotational plane, *mm*, as producing a tendency to *gyration*: which tendency can only be yielded to, consistently with undisturbed rotation of the fluid mass, by a *bodily* gyration of that mass.

tions, 240, note to p. 44); or they can be directly computed from an integration of the elementary attractions and couples, as Prof. Hopkins has done. In either way the result will be that the pressure-couple upon the shell is identical with that which *would* be exerted on the fluid mass *if solidified.* And *hence* upon the *shell* is exerted the entire precession-producing couple due to the entire mass. Hence the shell would initially have the precession due to this *total* couple acting upon its *partial* mass and moment of inertia. We may regard it, therefore, as *at the first moment* taking up this accelerated precession independently of the fluid. But this cannot continue for a finite time (however minute) without producing the *relative displacement* of shell and fluid, exhibited in the diagram, by which gyration, and, consequently, precessional motion, is impressed upon the fluid. In consequence, the fluid and shell take up a common precession, subject to the minute (relatively to each other) oscillations of their axes. In reacting against the shell we have seen that the fluid opposes the moment of inertia due to its mass, and thus, finally, the actual precession becomes that due to the *total* attraction-couple, combined with the *total* moment of inertia. Hence the resulting precession is the same as if the whole mass were solidified into rigid continuity; in other words, the existence of a fluid nucleus does not affect precession, *if the fluid be homogeneous.* This is Prof. Hopkins' result, as it is mine, though it is deduced by him from a minute analysis, which introduces into the differential equations for rotary motion (for shell and fluid separately) all the various elementary forces acting on each.

If we now take the case of heterogeneity of the fluid, we must, in the first place, assume that the strata of equal density are disposed according to the laws of equilibrium, having reference to the Figure of the Earth. That is to say, the strata will be concentric spheroidal surfaces of ellipticity differing slightly from that of the exterior by diminishing inwards with *increasing* densities. This will not, however, affect the reasoning which has been applied to relative displacement, as illustrated by the diagram, in the case of homogeneity. If the shell suffers a slight displacement relatively to the contained fluid, there will arise an interaction of which the *rationale* is identically the same as for the case of homogeneousness. The only question then, is, "Will the pressure-couple upon the shell developed in the fluid,

through the action of a foreign attraction, be identical with that which the attraction would produce upon the fluid if solidified?" I would answer by the affirmation: "Given a heterogeneous fluid wholly enveloped by a rigid boundary surface and subjected to a foreign attraction, and a condition of static equilibrium assumed, the pressure-couple exerted by the fluid on the shell cannot differ from that which the attraction would exert on the solidified fluid."* The assumed state of static equilibrium implies not only reference to the mutual attractions of the parts, but to the foreign attraction. Now, in the case of the heterogeneous earth, the conditions for this static equilibrium are very complicated, and though the distortion of stratification, which a heterogeneous earth-spheroid, wholly fluid, would undergo by the attraction, can be determined by use of transcendental analysis (the use of Laplace's coëfficients, now more commonly called *spherical harmonics*), I know no attempt to determine either the distortion of strata of an *enveloped* fluid (when, as in the case of the earth, the *mutual* attraction of the constituents of shell and fluid is to be taken into account) or the resulting pressures upon the envelopes. Prof. Hopkins has cut this Gordian knot by the simple process of integrating from centre to surface the foreign attraction, as a *free force* acting on the fluid particles; and it is not at all surprising that, obtained in this way, the resulting pressure-couple is *not* identical with that which would be developed by the attraction on the solidified fluid. On this fallacy, and this alone, depends his final and celebrated result. There are (besides the self-evident erroneousness of the process) two tests of its error. Applying the same process to determining the pressure-couple exerted on the shell by the agency of the centrifugal forces of diurnal rotation in the fluid particles, he gets, for the *action* and *re-action* of shell and fluid, in the case illustrated in the diagram, couples *not* identical. Again, his final formula for the precession of the earth, supposing it to consist of an interior heterogeneous spheroidal shell, gives (as I show, note to page 47, Smithsonian Contributions, 240) with decreasing internal ellipticities *less* precession (instead of greater, as he supposes) than would belong to entire solidity. Hence, increasing

*A denial of this, carried to its legitimate consequences, would involve, I think, a violation of law of the "conservation of energy." The slight motion of change of configuration which, in diurnal rotation, the strata must undergo to accommodate themselves to this condition of static equilibrium, is investigated by Prof. Hopkins, and found insignificant.

the thickness of the crust increases (if we accept his formula as a true exponent) instead of diminishing precession; and the actual deduction from it should be, that even *entire solidification* would not result in the diminished precession sought for. I further remark that the necessary identity of the interacting couples (upon shell and fluid), due to centrifugal forces in the fluid, indicates a correction for the pressure-couple exerted on the shell from that cause which, if likewise applied to the analogous computation for the pressure-couple developed by foreign attraction (the sources of the error of computation in both these cases, as before indicated, being the same), renders Prof. Hopkins' formula an exponent of the truth of my thesis, viz.: that precession is not affected by the hypothesis of internal fluidity, whether the crust and fluid be homogeneous or heterogeneous.

I shall conclude this paper, intended merely to give an easily comprehensible notion of the relation of internal fluidity to the precession of the earth, with the remarks appended to my discussion of Prof. Hopkins' analysis, in the Smithsonian Contributions already referred to.

1st. The analysis of Prof. Hopkins, in its application to a homogeneous fluid and shell, seems to establish (and the result is confirmed by its harmony with tidal phenomena, as already mentioned) that the rotation imparts to the fluid a *practical* rigidity by which it reacts upon the shell as if it were a solid mass, while its pressure imparts to the shell the requisite couple to preserve the precession unchanged.

2d. The same practical rigidity is, with entire reason, attributed to the heterogeneous fluid by which (leaving out of view minute *relative* oscillations which do not affect the mean resultant in other natural phenomena and should not in this) the shell and fluid take a common precession.

3d. The two masses retaining their configurations, mutual relations and rotary velocities, essentially unaltered by the hypothesis of internal fluidity, it would be a violation of fundamental mechanical principles were the resulting precession not identical with that due to the entire mass considered as solid.

4th. The common and identical precession of fluid and shell resulting from the analysis is indispensable to any conception of *precession* for the earth as composed of thin shell and fluid; for otherwise internal equilibrium would be destroyed and the "Figure

of the Earth" cease to have any assignable expression. The entire mass, fluid and solid, must (without invoking the aid of "viscosity") be "carried along in the precessional motion of the earth." Prof. Hopkins' analysis demonstrates the possibility, and exhibits the *rationale*, of such a community of precession, but fails in the attempt to exhibit a test of the existence or absence of internal fluidity.

5th. The powerful pressures that would be exerted upon a *thin* and rigid shell would probably produce in it noticeable nutational movements;* while if the shell be *not* of a rigidity far surpassing that of the constituents of the cognizable crust, the "precessional motion of the earth" would, owing to the neutralizing effect of tidal protuberances, scarcely be observable.

MUSICAL FLOW OF WATER. By H. F. WALLING, of Boston, Mass.

MR. Walling called the attention of the sub-section to a strong musical tone emitted by the faucet of one of the wash basins in the toilet room of the City Hall building, where the meetings were held. This tone could be made to vary about an octave, by slightly opening and closing the faucet. It only sounded when the flow of water was very small. The pressure of the water being modified by its motion, sudden closings, or partial closings of the valve took place, by which shocks like those of the water ram were produced. The pitch of the tone depended of course upon the rapidity with which the shocks succeeded each other. The range was from lower to middle C of the scale, corresponding to the production of from 256 to 512 shocks per second.

Mr. A. A. Breneman of Lancaster, Pa., alluded to the analogy between this action and that of musical flames, and said he was accustomed, when performing the experiments before his classes, to illustrate the cause of the latter by comparing the outrushing molecules to a flock of sheep running through a gate, when successive blockings up would occur, alternately followed by rushes.

*Without reference to conventional "Nutation," which is but a form of precession due to the non-coincidence of the plane of the moon's orbit and ecliptic. The "Nutations" referred to are explained in "Smithsonian Contributions," 240.

The Relation of the Dissipation of Energy to Cosmical Evolution. By H. F. Walling, of Boston, Mass.

The dissipation of energy is a continuous process, quite familiar to mankind in its main features and results, since the days of the ancient philosophers. It was recognized by them that all mechanical motions, being dissipated by friction, gradually diminish, and must finally cease unless maintained by external power. In the language of modern science the motion which thus disappears is converted from molar into molecular motion.

It may be added that molecular energy, existing mainly in the form called heat, tends to equalization or dynamic equilibrium, after the attainment of which it is powerless to produce molar or mechanical motion, a reconversion from the condition of equilibrium being impossible.

Accordingly the power to produce mechanical motion, exerted by the heat of the sun, which is being lavished with such prodigious prodigality, can only last while the sun continues to be hotter than other bodies in space. At present it is well understood that all terrestrial motive power is derived from this source with the single unimportant exception of that obtained from the tides, at the expense of the earth's energy of rotation. Among the more obvious processes of conversion of the sun's molecular into terrestrial molar motion, are the expansion and contraction of the atmosphere, the evaporation and condensation of water and the less direct method by restoration of potential chemical energy accomplished in vegetation, whence are produced food and fuel.

But it is supposed that the sun will finally grow cold, and that the resistance of the etherial medium, the evidence of whose existence is found in the demonstration of the undulatory theory of light, will cause satellites to fall into planets, planets into suns and suns into one common centre, after which, unless by special interposition of divine power, darkness, silence and death will forever prevail.

This gloomy prediction is of course inconsistent with the theory of continuous evolution, which obviously excludes from cosmical economy, catastrophes or extensive destructive effects.

A careful consideration, however, of the circumstances which will be likely to accompany the falling of a satellite into its planet may lead to the conclusion that this occurrence will not necessarily

be catastrophic. The process must certainly be an exceedingly *slow* one, no progress in it having been detected throughout all the recorded observations of the moon's motion extending over thousands of years. The only practical evidence which has been adduced to prove the resistance of a medium, namely, a very slight diminution in the period of that nearly evanescent body, Encke's comet, is very far from being definite and satisfactory. The mass of the moon being enormously greater, it is probable that many millions of years will pass before a diminution of her orbital period from this cause will be perceptible. The immense periods of time attributed to the past processes of geological evolution, and to the supposed metamorphoses of organic life, are therefore very brief when compared with those required for the returns of satellites to their parent orbs, admitting, as theoretical considerations seem to require, that such returns are ultimately inevitable.

The eccentricity being diminished by the resistance of a medium, the moon's orbit would eventually become, and afterwards continue, circular, so that final contact would be unaccompanied by violent collision. But before the time of actual contact, changes of form would be induced both in planet and satellite by mutual attractions, exemplified in the production of daily terrestrial *tides*. The investigations of Hopkins, Thomson, and recently of Barnard,* in regard to tidal and precessional influences, indicate that, even at the present distance of the moon, they must cause elongations and contractions of the solid materials of the earth, which are quite appreciable. A considerable diminution of the distance between the earth and moon would give rise to changes in the form of the earth, and hence to bendings to and fro of its external shell even if the earth were solid throughout. This would be accompanied by earthquakes and kindred disturbances far exceeding in magnitude and destructiveness anything of the kind now known to man. The frequency of these occurrences would be the same as that of the moon's meridian passage.

Resistances to this tidal action, however, would be developed, in consequence of which the molar motion of rotation would be converted into molecular motion, so long as the angular motion of rotation in either body was different from that of the moon's revolution, until the rotations became synchronous with the revolution, a condition already arrived at in the case of the moon. Syn-

* See this volume, Sec. A. p. 35.

chronism once attained would be permanent, acceleration both of revolution and rotation occurring as the distance diminished, and both at the expense of the potential energy of gravity between the two bodies. Each body presenting the same face to the other, no meridian passage could take place and hence no tidal action.

But there yet remains to be considered a continually increasing tendency to distortion of form consequent upon approach. This effect would be produced very gradually, being spread over such enormous durations of time. The curious and complicated foldings of the rocks, in the Appalachian regions, indicate that the solid materials of the earth are sufficiently plastic to allow it to take on any form towards which forces of sufficient magnitude direct it, provided the times be very greatly extended. Hence, considering the extreme slowness of the process, it may be reasonable to conclude that the forms ultimately developed would be identical with those which would be assumed by liquid masses having the same relative positions and velocities.

The determination of these forms is a problem for the mathematicians. In the absence of analysis, no reason is manifest for supposing that the forms of equilibrium would be materially different just before and just after contact. May it not be that the order of change would be a partial reversal of certain supposed processes of the nebular hypothesis? Thus the moon may be gradually elongated into a closed ring which will slowly contract upon the earth as the energy of angular velocity is gradually dissipated by the friction of the medium. In any event there seems to be no good reason to suppose that there will be such a sudden leap in the final osculation or embrace as would result in a catastrophe.

The same considerations apply to the gravitational relations between planets and suns. Other very important relations between these bodies, however, with which organic life is more especially concerned, require attention. One fundamental requisite to all known terrestrial organic life is the conversion, within living bodies, of molecular energy, either into molar motions, or into potential energy which may afterwards be thus converted. All living animals and plants, therefore, depend for their existence upon the passage through their bodies, of heat, light and other molecular forces originating in the sun, in the movement towards distribution and equalization.

The integrity of cosmical evolution in relation to organic life, accordingly, seems to require the maintenance of great central laboratories where molecular disturbances of sufficient intensity and quantity can be continually generated, and their effects distributed throughout the universe. Notwithstanding the enormous expenditure of heat by the sun its temperature is supposed to have been maintained about the same as at present for a very long period of time in the past, and no reason is manifest why this fixed temperature will not continue for a very long time in the future. Doubtless, operations are going on in the sun which it would be impossible to imitate in terrestrial laboratories. May it not be that the conditions of materials and the circumstances of pressure, chemical affinity, etc., are such, that substances more elementary than our so-called chemical elements are uniting with an energy far exceeding that of any chemical combination we can effect, and so prodigious as to maintain, at comparatively small expenditure of material, the sun's temperature at that enormous degree which marks the *dissociation* point of the tremendously energetic combination? The duration of the combination or combustion would thus be prolonged to an enormously remote period. At last when all the potential energy due to this particular reaction became exhausted by the combination of all the special materials required for it, new materials whose dissociation point had a lower temperature and which had consequently been prevented from combining previously, would commence upon a similar process of combustion. And so we may suppose combination to follow combination until finally, perhaps at a time when the planets, freighted with their living inhabitants, have begun to arrive at the sun's surface, long after the fires of the last combustion have expired, it has itself become a habitable globe, lighted and heated or served by other molecular forces from distant orbs, where new conditions cause new chemical combinations and conversions of newly developed potential energies.

Finally, giving play to the imagination, why may we not suppose farther, that in a universe extended throughout infinite space, processes of concentration, similar to those supposed in the nebular hypothesis and supplemented by processes like those here indicated, will go on forever, evolving worlds of continually increasing magnificence, perhaps inhabited by living occupants of inconceivably transcendent and ever expanding faculties?

DIRECTION OF WIND IN LOCAL THUNDER STORMS. BY HIRAM A. CUTTING, of Lunenburgh, Vermont.

IN July, 1850, at Franconia, N. H., I was exposed in a buggy to the fury of one of those local showers that pour rain in torrents, accompanied by some hail and much thunder and lightning.

As I was riding leisurely along I observed a small black cloud almost directly overhead. It increased with great rapidity, and in ten minutes the torrent came down. The wind was in gusts from all points of the compass, demolishing my umbrella in a twinkling, leaving me to the mercy of the elements. I was drenched in a moment and in an incredibly short space of time the body of the buggy was full and overflowing, though nearly four inches in height.

The roads were like rivers and everything was flooded. In driving north three and one-half miles I passed entirely out of the limit of the storm of hail and rain, but the wind for two miles farther had been violent from the south, prostrating corn and some trees and blowing down one barn. The next morning I repassed the ground and found that the southern limit of the storm was about six miles from its northern limit, and that at that part the wind was strong from the north, doing some damage.

In the afternoon, I visited the iron ore hill in Lisbon, which lies west of the centre of the shower, and found the wind there had been strong from the east. Upon my return I examined carefully by the plants and trees, and by inquiry, into the direction of the wind and found it upon the westerly side, in every instance direct from the storm and all described it as cool, though the forenoon of the day of the shower was very hot and sultry with so little wind that I was unable to learn its direction.

As the eastern limit of the storm was towards the White Mountain range and a wilderness, I could get no information of its extent or severity, except by the rise of the streams fed by it, which was very great on all little streams, within or running through the limit of a circle six miles in diameter.

Upon my return home to Concord, Vt., I resolved to investigate fully the next storm of similar import. I soon removed to Lunenburgh, where I now reside, but saw nothing of similar storms until June 30, 1856. The morning was sultry, the forenoon hot, with thermometer at 98°. The wind was unsteady, but from south-

erly points. At about noon a dark low cumulus cloud appeared in the west, which rapidly increased in size, until it hung with inky blackness over the east part of Concord about five miles away. At noon, there was a strong breeze from the east, setting directly towards this cloud and quite steady. At one o'clock P. M., there was a hard gusty wind blowing directly from the shower, feeling quite chilly after the forenoon heat and causing the thermometer to fall in a few minutes to seventy degrees.

The cloud hung over the same place for half an hour longer, when it became lighter and was soon broken up in fragments and dissipated. During the afternoon, small showers came up round about and at three it rained slightly at Lunenburgh.

The next morning, hearing reports from the hail storm, I went to the field of disaster. I found the storm of great severity but of limited extent, being all within the radius of one-half mile. When within a mile of the storm there were indications of a strong wind from the west (I was approaching from the east) sufficiently so to blow down many trees beyond the limit of the hail and rain. I found, upon examination, some trees blown down upon every side of the storm, yet the wind invariably from the storm cloud. Upon inquiry, I found the wind, as far as noticed before its commencement, blew directly towards it from all quarters. The storm, though so limited, was of unusual violence, in fact almost without precedent in this section. The lightning was terrific, striking trees, etc. The testimony showed the thunder the heaviest ever known and almost incessant.

The cloud, to the parties living there, seemed, as it appeared to me five miles distant, to form directly overhead; the atmosphere seemed very sultry while it was forming, with hardly a breath of air. I could not learn that there was any special direction of the wind and think there was not enough to note. The cloud formed so rapidly, that the farmers in their fields did not leave their work until an almost total darkness settled down upon them, yet with the opportunity of seeing a band of clear sky in all directions, at the horizon. There was a strange feeling of oppressiveness in the atmosphere. When the storm commenced at one o'clock P. M., a complete deluge of water first came down, followed almost immediately by hailstones and chunks of ice several inches in diameter which seemed pressed to earth, with a violent wind crushing branches down from the trees with fearful violence. The duration

of the storm was no more than thirty minutes, yet in a circle one mile in diameter no green thing was left. The leaves, branches and even the bark, were stripped from the orchards and shade trees. A sugar orchard standing in the storm was destroyed in the same manner. The shingles from the roofs and some boards were battered from the buildings and broken in pieces by the ice. The glass and sashes were all broken. The grass crop was entirely destroyed so that the grass fields looked like ploughed ground and it was next to impossible to find straws more than two inches long. What became of the heavy crop of grass, ready for the harvest, I cannot say.

Potatoes well hilled up by twice hoeing were destroyed and the ground levelled as though it had been done with a roller, and no stalks of potatoes or corn could be found upon all the ground. The hailstones and masses of ice were piled up like snow drifts in winter; and twenty-four hours after the storm, in one drift by actual measurement there were over twenty-five cords. Upon the outer edge of the storm where the outward wind was strong there was only rain, and a mile from the centre there was only wind, which extended at least from five to eight miles away; how much farther I cannot say. The section, over which the hail fell, was left without a particle of verdure. No green leaves could be found. It presented a state of devastation, as though the trees had all been stripped and the earth ploughed, and then pounded down.

During the ensuing week, there were several storms similar in their formation, and all accompanied with vivid lightning, heavy thunder, hail and rain, but of much less severity than the one described.

After this peculiar series of storms, there were no marked instances of storms of this character until 1872. August 14th, of that year, the town of Sheffield, Vt., was visited by a local storm of great severity. From the oppressive heat and calm of the morning, clouds rapidly formed and hanging stationary overhead the storm between nine and ten A. M. burst upon the place.

This storm was of much greater extent, covering a section of country five or six miles in diameter. These clouds continued to send down their deluge of rain and hail for three hours. Small brooks were changed to streams ten or twelve feet deep. The bridges were all swept away. The lightning struck several times

and several farms had fields of acres in extent washed away, and other land was covered by the débris to the depth of six or eight feet.

In the central part of the storm the wind blew in gusts from all points of the compass, and outside of the storm the wind first set towards the cloud from all points; then from it, as before described, seeming very cool. During the afternoon, showers spread about the country in all directions, but in usual form and not of unusual severity.

Sept. 8th, a similar storm came directly under my observation in the northern part of Lunenburgh. Though of great violence one mile north of my place, I was enjoying sunshine. As in other cases, it seemed to form overhead and remain stationary. The weather as before described. No perceptible wind, but vane pointing southwest. At the first formation of the cloud, the wind set towards it in a steady breeze; then from it, cool and gusty. In the area of the storm the rain and hail fell in torrents and the darkness was almost like that of night.

Having been led, by former observations, to know what I might expect, I was on the ground almost as soon as the rain ceased. I found, fifty rods within the storm, the roads washed out so as to be impassable, and leaving my horse, I walked where water would permit. The apples and most of the leaves were knocked off the apple trees by the hail though the hailstones were not large. Grain not harvested was spoiled. Lightning struck but once within the area of the storm, though the flashes were described as incessant. Everything showed a great waterfall, though it was nowhere measured; around the skirts of the storm the wind was cool and outward, blowing quite a gale for several miles. A portion of the storm cloud passed off to the southwest, showering moderately.

These of course are marked instances, yet many have noticed a tendency to first an inward and then an outward wind in hard showers, while those passing rapidly over the country, as the saying is, pass against the wind. It however shifts a few minutes before the rain falls. After a shower has passed, it frequently leaves a delightful cool breeze blowing from it. At the sides of those showers, however, the wind is fitful and gusty, seldom blowing directly to or from them.

I respectfully present these facts for consideration, hoping that

others may observe them until the theory of hail storms and local showers of great severity is better understood.

I give no theory but let the facts stand out for consideration as to whether they may not lead to a better understanding of the formation of such storms.

On the Silt Analysis of Soils and Clays. By Eug. W. Hilgard, of Oxford, Mississippi.

Among the objections raised against the utility of soil analyses as mostly made and stated heretofore, not the least serious one is that they do not indicate with any reasonable degree of accuracy, or in a generally intelligible manner, those important points in the physical condition of soils which are practically designated as "lightness," "heaviness," "openness," etc. Indeed, the very idea of what constitutes a sandy soil or a clay soil is exceedingly indefinite; necessarily so, so long as the constituent ideas of "clay" and "sand," respectively, remain so ill-defined.

It makes a material difference whether the grains of sand contained in the soil or clay are prevalently half a millimeter in diameter, or the tenth or twentieth part of that amount. Sand (or more properly silt) of the latter size is by no means impalpable; and yet a soil containing 50 per cent. of this substance might be exceedingly "heavy," while it would be "light" if the sand grains approached $0{\cdot}5^{mm}$ diameter. And it would make an equally material difference whether or not the impalpable matter usually classed as "clay" were really, in the main, hydrous silicate of alumina, or simply silex, or other mineral powder.

Equally important are, of course, the corresponding differences in the properties of clays intended for use in the arts.

In the prosecution of my researches on the soils of the state of Mississippi, I found myself confronted by these difficulties, and by the necessity of providing for some mode of operation, and means of designating the several physical constituents of soils, which should not only insure more accurate results, but should also render these capable of ready comparison all the world over.

I need not recapitulate the often discussed objections to Nöbel's apparatus, with its four vessels of ever-varying capacity and slope of sides, and variable head of pressure. Not one of the five sediments obtainable by its use is ever of a character approaching uniformity; and, even in one and the same instrument, successive analyses of one and the same material differ widely in their results.

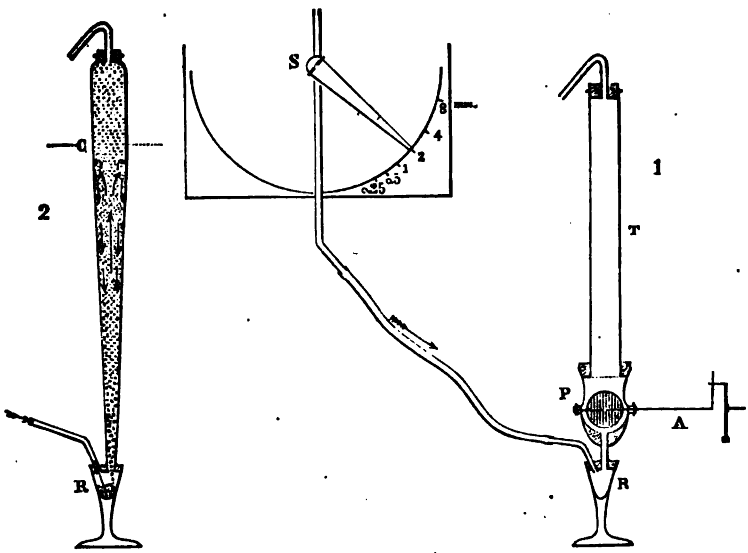
Schultze's elutriating apparatus, as modified and used by Fresenius in his investigations of the clays of Nassau — a tall, conical champagne glass, with an adjustable stream of water descending through a tube in the axis — answers a better purpose; but offers the inconvenience of the accumulation of heavy sediments around the mouth of the tube, whereby not only the velocity of the stream is changed, but its failure, at low velocities, to agitate the whole mass of substance under treatment, allows portions of the latter to escape the elutriating action altogether. And since in soil analysis special importance attaches to these finer sediments, which are carried off at low velocities, this objection is a capital one.

Intending to carry out in a convenient form the idea (already urged by Türrschmidt, Notizblatt, v, 180) of substituting for the accidental and indefinite products usually appearing in the statements of silt-analyses, sediments of known and definite "hydraulic value," I adopted in place of a variable head of water, a constant one (a Mariotte's-bottle arrangement, adapted to ten-gallon carboys), modifiable by means of a stopcock with a long lever moving on a graduated arc, on which the positions corresponding to given velocities in vessels of known cross-section of mouth are marked off according to empirical determinations.

In order to obviate the inconvenience arising from the accumulation of sediment around the orifice of the tube delivering the current, I introduced an intermediate conical relay reservoir (R, fig. 2; a test glass, cut short) at the point of the elutriator (inverted) cone. The smallness of the lower orifice of the latter renders the current there sufficiently rapid to prevent any portion of the sediment concerned at a given velocity from falling into the relay; and whatever sediment does accumulate there can at any time be stirred and brought back into the elutriating vessel, by increasing the velocity for a few seconds of time.

Following up with the microscope the character of the sediments

so obtained with the apparatus, fig. 2, I soon found that they were throughout of a very mixed nature; and searching for the cause, I found one in the abruptly conical termination of the elutriator, at C, where the efflux tube was at first attached. For, in that case, the ascending current does not decrease regularly its velocity as the cone expands, but is broken up into a complicated system of eddies, whose general tendency is to ascend in the axis of the instrument, and descend at its sides. So far, therefore, from corresponding to the calculated velocity belonging to the cross section



Plain Elutriator,
with Conical Tube and
Hydraulic Stirring.

Churn Elutriator,
with Cylindrical Tube and
Rotary Stirrer.

at C, the sediment carried off represents the variable effects of these eddies.

The obvious remedy was to adapt to the wide (upper) end of the elutriator tube a cylindrical portion, as shown in the diagram, above C. When the length of this cylinder is made not less than ·125^{mm}, no perceptible eddies reach the efflux tube; and the sediments exhibited a pretty satisfactory uniformity of grain, save in so far as the coarser ones still contained a good deal of fine material.

However, in subjecting the workings of the instrument to the test of the balance, I found the results still quite unsatisfactory,

and apparently inconsistent, especially as regards the finer sediments.

The cause of these anomalies became apparent upon attempting to work over, the second time, a quantity of sediment originally obtained at the velocity of 1^{mm} per second. It should all, of course, again have passed over at the same velocity; but to my surprise, barely one-half of it did so, while a heavy coarse sediment collected in the lower portion of the elutriating tube, and even settled into the relay reservoir R; as roughly shown in fig. 2. On returning the portion that had passed over to the elutriating vessel, the same phenomenon recurred; and by repeated "cohobation," I finally succeeded in getting about four-fifths of the whole quantity of sediment settled into the relay reservoir!

On examination I found this coarse sediment to consist of flocculent aggregates of from a few to as many as thirty fine particles of siliceous silt. When violently shaken, they part company and become diffused, singly, through the liquid, which then presents simply a general turbidity; the particles then settling down slowly and singly, at the rate corresponding to their individual size or hydraulic value.

The process of formation of these aggregates may be observed by means of a lens, in all its stages; it being the effect of the downward currents always existing on the sides of the conical vessel, as heretofore mentioned. The aggregation progresses slowly at first; but when once five or six particles have thus coalesced, they begin to descend with increased rapidity, and, growing, avalanche fashion, as they roll down, finally drop through the narrow lower orifice, despite the rapid current existing there, into the relay reservoir R.

I have vainly attempted to obviate this trouble in various ways. Even when a central core is introduced in the axis of the conical tube, so as to force up the current close to the sides, return currents *will* form, and with them these miniature avalanches.

It is obvious that this circumstance completely vitiates all determinations heretofore made in conical vessels; whether those of Nöbel's apparatus, or those of Schultze and Fresenius; or even the later ones of Müller, and of Schöne;* in all of which the agitation produced by the current is alone employed for stirring.

*I regret having been unable to obtain, for reference, the original papers of the last two authors; the most thorough, probably, heretofore published on this subject.

The tendency to coalescence diminishes, of course, as the size of the grains increases; but does not altogether cease until their diameter exceeds $0{\cdot}2^{mm}$, or about 16^{mm} hydraulic value. For the elutriation of coarser sediments, hydraulic stirring may be successfully employed. For finer sediments, however, the use of *cylindrical* vessels, and of *rapid agitation by outside power*, seems indispensable.

Fig. 1 of the diagram shows, on a somewhat enlarged scale, the instrument I have devised, with this end in view. The cylindrical elutriating tube T, of $34{\cdot}8^{mm}$ inside diameter at its mouth, and 290^{mm} high, has attached to its base a rotary churn P, consisting of a porcelain beaker triply perforated, viz: at the bottom, for connection with the relay reservoir R; and at the sides, for the passage of a horizontal axis A, bearing four grated wings. This axis, of course, passes through stuffing boxes, firmly cemented to the roughened outside of the beaker, and provided with good, thick leather washers, saturated with tallow. These washers, if the axis run true, will bear a million or more of revolutions without material leakage. From five to six hundred revolutions per minute is a proper velocity, which may be imparted by clock-work, or a turbine.

As the whirling agitation caused by the rotation of the dasher would gradually communicate itself to the whole column of water, and cause irregularities, a (preferably concave) wire screen of $0{\cdot}8^{mm}$ aperture is cemented to the lower end of the cylinder. No irregular currents are then observed beyond about 75^{mm} above the screen, whose meshes are yet sufficiently wide to allow any heavy particles or aggregates to sink down freely. Any grains too coarse to pass must, however, be previously sifted out.

Thus arranged, the instrument works quite satisfactorily; and by its aid, soils and clays may readily be separated into sediments of any hydraulic value desired. But in order to insure correct and concordant* results, it is necessary to observe some precautions, to wit:

1. The tube of the instrument must be as nearly cylindrical as possible, and must be placed and maintained in a truly vertical position. A very slight deviation from the vertical at once causes the formation of return currents, and hence of molecular aggregates, on the lower side.

*Usually within 5 per cent. of the quantities found.

2. Sunshine, or the proximity of any other source of heat, must be carefully excluded. The currents formed when the instrument is exposed to sunshine will completely vitiate the results.

3. The Mariotte's bottle should be frequently cleansed, and the water used be as free from foreign matters as possible. For ordinary purposes, it is scarcely necessary to use distilled water; the quantities used are so large as to render it difficult to maintain an adequate supply; and the errors resulting from the use of any water fit for drinking purposes are too slight to be perceptible, so long as no considerable development of the animal and vegetable germs is allowed. Water containing the slimy fibrils of fungoid and moss prothallia, vorticellæ, etc., will not only cause errors by obstructing the stopcock at low velocities; but these organisms will cause a coalescence of sediments that defies any ordinary churning, and completely vitiates the operation.

4. The amount of sediment discharged at any one time must not exceed that producing a moderate turbidity. Whenever the discharge becomes so copious as to render the moving column opaque, the sediments assume a mixed character; coarse grains being, apparently, upborne by the multitude of light ones whose hydraulic value lies considerably below the velocity used; while the churner also fails to resolve the molecular aggregates which must be perpetually re-forming, where contact is so close and frequent.

This difficulty is especially apt to occur when too large a quantity of material has been used for analysis, or when *one* sediment constitutes an unusually large portion of it. In either case, a portion of the substance may be allowed to settle into the relay reservoir, until the part afloat in the churn and tube is partly exhausted; after which, the rest can be gradually brought up and worked off. Or, the sediments shown by the microscope to be much mixed, may be worked over a second time. Either mode, however, involves so grievous a loss of time, as to render it by far preferable to so regulate the amount employed, that even the most copious sediments can be worked off at once. Within certain limits, the smaller the quantity employed, the more concordant are the results. Between ten and fifteen grams is the proper amount for an instrument of the dimensions given above.

I have found that, practically, $0{\cdot}25^{mm}$ per second is about the lowest velocity available within reasonable limits of time; and

that by successively doubling the velocities, up to 64^{mm}, a desirable ascending series of sediments is obtained; provided always, that a proper previous preparation had been given to the soil or clay.

Preliminary Preparation.—As regards this point, which is of capital importance, I premise that I find the usual precept of boiling from thirty to sixty minutes, almost absurdly inadequate to perform that loosening of the adherence of particles, which is the fundamental condition of success in any process of mechanical separation. In no case have I found less than six hours' incessant and lively boiling even approximately sufficient; and, even with double that time, so much of the disintegration is often left to be done by the churner of the instrument, as to protract indefinitely the exhaustion of the finer sediments, which are then continually being set free from the coarser portions. Thus, in average cases the sediment of $0{\cdot}25^{mm}$ h. v. may be "run off" in the course of thirty to thirty-five hours. But in one case, after twelve hours' boiling, the 0·25 sediment gave no sign of disappearance after thirty-six hours, and continued to come off for fifty-four hours more, with the coarser sediments.

It is therefore a material saving of time, and essentially promotive of accuracy, to effect the mechanical disintegration in the most thorough manner, beforehand. This can rarely be done without long protracted boiling, and the subsequent use of mechanical means (kneading) on the finest sediments. But I cannot see the propriety of using chemical solvents for disintegration, unless the investigation is to extend beyond the physical properties of the substance treated. The miniature Loess puppets, consisting of sand-grains cemented by carbonate of lime; the grains of bog ore, or alumino-siliceous aggregates found in some soils, fulfil, physically, the same office as solid sand-grains of corresponding size; and should appear as such in the analytical statement.

The presence of clay in the instrument would materially interfere with the proper separation of sediments. In consequence of its property of indefinitely fine diffusion in water, clay—*i. e.*, the hydrous silicate of alumina—produces the same effect as would the dissolution of a salt, viz: increases the buoyant effect, and therefore the hydraulic efficacy of water, to such an extent as to enable it to carry off, *e. g.*, sediment pertaining to the velocity of 1^{mm} in pure water, when the actual velocity is but $0{\cdot}25^{mm}$.

In view of these facts, I have adopted the following course of preliminary treatment:

1. Boiling briskly, for twenty-four to thirty hours, fifteen to twenty grams of weighed "fine earth."

This is best done in a thin, long-necked flask of about one litre capacity, filled four-fifths full of distilled water, and laid on a stand at an angle of 40–45°. It is provided with a cork and condensing tube of sufficient length (five to six feet) to condense all or most of the steam formed when lively ebullition is kept up by means of a gas flame. For the first few hours, the boiling generally proceeds quietly; but as the disintegration progresses, violent bumping sets in, which sometimes endangers the flask, but is of material assistance for the attainment of the object in view. In extreme cases, some of the heavier sediment (generally clean sand) may be removed from the flask; but this is undesirable. It is frequently the case that when the boiled contents are left to settle, the liquid appears perfectly clear within an hour; although so soon as they are largely diluted, the clay becomes diffused as usual, and will not settle in weeks. Probably this is owing to the extraction from the soil of soluble salts, which exert the same influence as does lime or common salt, even in very dilute solutions.

2. The boiled fluid and sediment is transferred to a beaker, and diluted so as to form from one to one and one-half litres in bulk; and being stirred up, is allowed to settle for such a length of time as (taking into account the height of the column) will allow all sediment of $0{\cdot}25^{mm}$ hydraulic value to subside; the process being repeated with smaller quantities of fresh water, until no sensible turbidity remains after allowing due time for subsidence.

It must be remembered that this time is considerably longer than that for pure water, so long as any considerable amount of clay remains in the liquid, rendering it specifically heavier. And as the precise amount of allowance to be made cannot in general be foreseen, some sediment of, and exceeding, $0{\cdot}25^{mm}$ h. v. will almost inevitably be decanted with the successive clay waters, until the buoyant effect of the clay becomes insensible. The united clay waters (of which there will be from four to eight litres) must therefore be again stirred up, and the proper time allowed for the sediments of $0{\cdot}25^{mm}$, and over, to subside. The dilution being very great, a pretty accurate separation is thus accomplished; the sediments being then ready for the elutriator.

Treatment of the "Clay Water."—I have based on the well-known property of clay, of remaining suspended in pure water for weeks and even months, an obvious method of separation from at least the greater portion of silts finer than $0 \cdot 25^{mm}$ hydraulic value ($< 0 \cdot 25$).

The clay water is placed for subsidence in a cylindrical vessel (in which it may conveniently occupy 200^{mm} in height), and is there allowed to settle for at least twenty-four hours. This interval of time was at first chosen arbitrarily; but I subsequently found it to be about the average time required by the finest siliceous silt usually present in soils, to sink through 200^{mm} of pure water. So long as any sensible amount of clay is present, the time of course is longer, say from forty to sixty hours, or even more, if the clay be abundant and the liquid not very dilute. The sharp line of separation between the dark silt-cloud below and the translucent clay water above is readily observed, and the time of subsidence regulated accordingly. At times, several such lines of division may be seen simultaneously in the column, indicating silt of successive sizes, with a break between. No such appearance is presented when, after weeks of quiet, the clay itself gradually settles. The liquid, which may be almost clear at the surface, then shades off downward very gradually, until, near the bottom of the vessel, it becomes entirely opaque.

After decantation of the clay water, the remaining liquid is poured off temporarily, leaving the sediment as dry as possible. It is then rubbed or kneaded in the decanting vessel itself, with long handled rubber pestle (conveniently cut out of a car spring). Water is again poured on (agitating as much as possible, to break up the molecular aggregates) to the proper height, and another twenty-four hours subsidence allowed. This operation is repeated (six to nine times), until either the water remains almost clear after the last subsidence, or the decanted turbid water fails to be precipitated by salt water.

It thus seems possible, by a large number of successive decantations, to separate pretty sharply the clay proper from the fine silts. But the amount of time and care required in the process of complete separation is so great, and the difference of percentage resulting from a neglect of the subsidence beyond twenty-four hours is in most cases so slight, that in the analyses made thus far, I have throughout adhered to the twenty-four hours interval;

the "clay" thus obtained being, of course, more or less contaminated with some of the finest silt; which is precipitated with it by salt, provided the relative amount of clay is not too small. Otherwise a slight turbidity may remain for several days in the decanted liquid, which cannot then be cleared by the further addition of salt.

50^{ccm} of a saturated brine (*i. e.*, 1·5 per cent. of salt) is ordinarily sufficient to precipitate one litre of clay water; the precipitation is much favored by warming. Half the quantity, or even less, will do the same, but more time is required, and the precipitate is more voluminous.

As it cannot ordinarily be washed with pure water, it must be collected on a weighed filter, washed with weak brine, dried at 100° and weighed. It is then again placed in a funnel and washed with a weak solution of sal ammoniac, until all the chloride of sodium is removed. The filtrate is evaporated, the residue ignited and weighed: its weight, *plus* that of the filter, deducted from the total weight, gives that of the clay itself.

In some cases, especially of clays and subsoils deeply tinged with iron, the clay, *after drying at* 100°, will not readily diffuse in water, and can be washed with pure water until free from salt; it can then of course be weighed directly.

Properties of Pure Clay.—The "clay" so obtained is quite a different substance from what usually comes under our observation as such; since its percentage seems rarely to reach 75 in the purest natural clays, 40 to 47 in the heaviest of clay soils, and 10 to 20 in ordinary loams. Thin crusts of it are occasionally found in river bottoms, where clay water has, after an overflow, gradually evaporated in undisturbed pools. When freshly precipitated by salt it is gelatinous, resembling a mixed precipitate of ferric oxid and alumina. On drying, it contracts almost as extravagantly as the latter, crimping up the filter, to which it tenaciously clings; and from which it can be separated only by moistening on the outside, when it may mostly, with care, be peeled off.

After drying, it constitutes a hard, often horny mass, difficult to break, and at times somewhat resonant. Since the ferric oxid with which the soil or clay may have been colored is mainly accumulated in this portion, it usually possesses a correspondingly dark brown or chocolate tint. When a large amount of iron is present, water acts rather slowly on the dried mass, which grad-

ually swells, like glue, the fragments retaining their shape. Not so when the substance is comparatively free from iron. It then swells up instantly on contact with water; even the horny scales adhering to the upper portion of the filter quickly lose their shape, bulge like a piece of lime in process of slaking, and tumble down into the middle of the filter.

There is a marked difference, however, in the behavior with water of clays equally free from ferric oxid; some exhibiting the phenomena just described in a much more energetic manner than others. On the whole, those freest from iron appear to imbibe the water, and crumble, most readily. Inasmuch as this property possesses highly important bearings, both on the agricultural and ceramic qualities of clays, I propose to investigate it more minutely hereafter.

The pure clay, when dry, adheres to the tongue so tenaciously as to render its separation painful. When moistened and worked into the plastic condition, it is exceedingly tenacious and "sticky," adhering to everything it touches.

Under a magnifying power of 350 diameters, no definite particles can be discovered in the opalescent clay water remaining after several weeks' subsidence. The precipitate formed by saline solutions then appears as an indefinite cloud (mostly of a yellowish tint), for which one vainly seeks a better focus. In stronger clay water one can discern a great number of indefinite punctiform bodies, very uniformly diffused throughout the liquid, and apparently opaque; the precipitate then formed by brine also shows a faintly dotted structure of its clouds.

Doubtless the fine silt obtained in the twenty-four hours' subsidence, the diameter of whose quartz particles varies from 0·001 to 0·02 of a millimeter, is not entirely free from adherent clay; as is indicated by its deeper tint, compared with that of the coarser sediments. The extent to which this contamination exists, the possible means of further separation, and the distribution of the important soil ingredients among the several sediments, I reserve for future discussion.

Separation of the Coarser Sediments.—The mixed sediments remaining after the separation of the clay, and silts of less than $0{\cdot}25^{mm}$ hydraulic value ($< 0{\cdot}25$), by decantation, are transferred to the elutriator, after separating by means of a sieve, such as, being of more than $0{\cdot}8^{mm}$ diameter, would fail to pass through the wire

screen, and thus interfere with the operation. The water should previously have been let on, so far as to stand above the screen; otherwise some sediment may be forced back into the rubber connecting tube.

The Fine Sediments.—The operation is best begun by running up the column rapidly nearly to the cork, allowing a few seconds' subsidence, and then setting the index to the proper velocity, of $0{\cdot}25^{mm}$ per second at the beginning. At first the sediment passes off rapidly, and the column remains obviously and evenly turbid, from the point where the agitation caused by the churner ceases, to the top. But this obvious turbidity generally exhausts itself in the course of a few hours, and it then requires some attention to determine the progress of the operation. I have never known the $0{\cdot}25^{mm}$ sediment to become exhausted in less than fifteen hours, and in one case it has required ninety. The more rigorously the process of preliminary disintegration, above described, has been carried out, the shorter the time required for running off the fine sediments, which otherwise tax the operator's patience severely. In matter of fact, they never do give out entirely; doubtless for the reason that the stirrer continues to disintegrate compound particles which had resisted the boiling process. Besides, downward currents on the sides of the vessel *will* form, despite all precautions; so that the interior surface of the cylinder becomes coated with pendent flakes of coalesced sediment. These must from time to time be removed by means of a feather, so as to bring them again under the influence of the stirrer; but it is, of course, almost mathematically impossible that, under these circumstances, any of the sediments subject to coalescence should ever become completely exhausted. Practically, the degree of accuracy attainable at best, renders it unnecessary to continue the operation beyond the point when only a fraction of a milligram of sediment comes over with each litre of water. It is admissible, and even desirable, to run off rapidly the upper third of the column at intervals of fifteen to twenty minutes; whereby not only time is gained, but also the sediment in the reservoir is stirred and brought under the influence of the churner, for more complete disintegration.

It is noticeable that recent sediments—river alluvium, etc.—are much more easily worked than more ancient ones; as might be expected.

Up to 4^{mm} hydraulic value, the use of the rotary stirrer is indispensable, on account of the tendency to the formation of compound particles. Beyond, this tendency measurably disappears, so that for the

Coarse Sediments of 8 to 64^{mm}, hydraulic stirring may be employed, and an elutriating tube of smaller diameter may advantageously be substituted, in order to diminish the otherwise somewhat extravagant expenditure of water. The entire amount required for one analysis is from 25 to 30 gallons; provided a thorough previous disintegration has been secured. The average times required, are as follows:

Sediment	$0{\cdot}25^{mm}$	30 to 40^h
"	$0{\cdot}5^{mm}$	15 to 25^h
"	$1{\cdot}0^{mm}$	5 to 10^h
"	2 to 64^{mm}	6 to 10^h
Total,		56 to 85^h

With proper arrangements, much of this can be done automatically, at night; completing an analysis (except the clay and finest silt determinations) in the course of three or four days.

As the soils are most conveniently weighed "dried at 100°,"* I have always weighed the sediments in the same condition. Great care is necessary to obtain the correct weight of the (extremely hygroscopic) clay; the same is true, more or less, of the $<0{\cdot}25$ sediment, which, moreover, is so diffusible in water that it cannot readily be collected on a filter. I find it best, after letting it subside into as small a compass as possible, to evaporate the last $25–50^{ccm}$ in the platinum dish in which it is to be weighed.

From the other sediments, the water may be decanted so closely as to render their determination easy.

The loss in the analysis of clays and subsoils, containing but little organic or other soluble matter, is usually from 1·5 to 2·0 per cent., resulting partially, no doubt, from the loss of the fine silt which comes off more or less throughout the process, and is decanted with the voluminous liquid. When the turbidity is marked, it indicates imperfect preliminary disintegration; it may be removed, and the silt collected, by adding a weighed quantity

* A somewhat clayey soil will continue to lose weight at 100°, for 5—6 days. But after the first 6 hours the loss becomes insignificant for the purpose in question.

of alum (about 25 milligrams per litre is sufficient) precipitating with carbonate of ammonia, and deducting from the weight of the (flocculent) precipitate the calculated amount of alumina.

The analysis of soils rich in vegetable matter involves some modifications in the preliminary treatment and final weighings, which I shall not now discuss. Ignition of the soil previous to elutriation, as proposed by some, is obviously inadmissible, as it would render impossible the separation of the clay from the finer sediments.

As I have heretofore stated,* I consider that, ordinarily, the investigation of the *subsoils* is better calculated to furnish reliable indications of the agricultural peculiarities of extended regions, than that of the surface soils, which are much more liable to local "freaks and accidents," and usually differ from the corresponding subsoils in about the same general points. For practical purposes, therefore, the difficulties incident to the treatment of soils rich in humus, may in most cases be avoided.

Character of the Sediments.—As regards the size of the particles constituting the successive sediments, the most convenient, because almost universally present, material for reference is quartz sand. I give below a table of measurements, concerning which I remark that the values given refer to the largest and most nearly round quartz grains to be found in each sediment, and to scale divisions of $\frac{1}{180}$ millimeter each.

As a matter of course, all sizes between that given and the one next below, are to be found in each sediment. A few grains of the finer sediments are also invariably present, owing both to the progressive disintegration of conglomerated particles by the stirrer, and to the inevitable formation of the avalanche-like aggregates of the finer sediments.

While the measurement of the quartz grains, which are rarely wanting in a soil or clay, affords sufficient landmarks to the scientific observer, it seems desirable to attach to them, besides, generally intelligible designations, which shall approximately, at least, indicate the nature of the sediment. This I have attempted in the table, which is in this respect, of course, open to criticism; since it is not easy to indicate in popular language, distinctions not popularly made.

* Am. Jour. Sci., Dec., 1872; Proc. Am. Assoc. Adv. Sci., 1872, p. 71.

Table of Diameters and Hydraulic Values of Sediments.

No.	Designation of materials.	Diameter of quartz grains.	Velocity pr. sec., or hydraulic value.
1.	Coarse Grits,	1—3 mm	?
2.	Fine "	0·5—1 "	?
3.	Coarse Sand,	80—90 ($\frac{1}{100}$) "	64 mm
4.	Medium "	50—55 "	32 "
5.	Fine "	25—30 "	16 "
6.	Finest "	20—22 "	8 "
7.	Dust "	12—14 "	4 "
8.	Coarsest Silt,	8—9 "	2 "
9.	Coarse "	6—7 "	1 "
10.	Medium "	4—5 "	0·5 "
11.	Fine "	2·5—3·0 "	0·25 "
12.	Finest "	0·1—2·0 "	<0·25 "
13.	Clay "	?	<0·0023 "

I remark that the absolute diameter of the elutriator tube exerts a sensible influence on the character of the sediments, in consequence of the comparatively greater friction against the sides in a tube of small diameter. Strictly speaking, none of the sediments actually correspond to the velocity calculated from the cross section of the tube and the water delivered in a given time, but to higher ones, whose maximum is in the axis of the tube, and which gradually decrease toward the sides, according to a law which may be demonstrated to the eye by slightly diminishing the velocity while a sediment is being copiously discharged, so that the turbid column remains stationary, while clear water is running off. The surface then assumes a paraboloid form, which is sensibly more convex in a tube of small diameter than in a wide one; the results obtained in the latter being, of course, nearest the truth.

Still, the accompanying samples of sediments from Mississippi soils and subsoils show at once, even to the naked eye, that the assorting process has been quite successful, and that the prominent characteristics of soils in these respects may thus be determined and exhibited to the eye, with a very satisfactory degree of accuracy.

I reserve for future communications the detailed discussion of the services which this method of analysis is capable of rendering to the theory and practice of both agriculture and the ceramic art. But I feel confident that the comparative neglect of the subject of

soil analysis during the past decennium, was the result of hasty judgment, and that, by properly combining the examination of the physical and chemical properties of soils and clays, we shall be able to fulfil, in a great measure, the high expectations entertained in the early days of agricultural chemistry.

The important bearing of the phenomena of "molecular coalescence" upon the formation of natural sediments, is too obvious to require discussion. It explains at once why we so rarely find a deposit composed of particles of uniform hydraulic value, however favorable to such a result may have been, apparently, the circumstances attending its formation. And it warns us to be careful in our estimate of the nature and velocity of depositing currents, as deduced from the character of the sediments.

In previous papers on the Quaternary formations of the lower Mississippi Valley, I have called attention to the somewhat singular composition of the material characterizing the Bluff or Loess group, which fails to show any marks of assorting or stratification of materials, even in profiles of seventy feet; although it consists of all grades of silt and sand from $\frac{1}{100}^{mm}$ upward. The uniform intermingling of these ingredients ceases to be surprising, when we consider that, under the influence of the slow eddying motion of shallow and uniformly slow-flowing water, the finest particles may assume the hydraulic value of very coarse ones, and be deposited with them. We thus, *a posteriori*, arrive at the same conclusion concerning the circumstances under which this deposit was formed, as had been previously deduced from geological data alone.

As might be expected, the temperature of water exerts a strong influence on the coalescence of particles. It is sensibly less in hot water, so long as the water is either strongly agitated, or perfectly quiescent. But the circulating motion set up in hot water exposed to cooling influences very soon effects coalescence, and consequent clearing of a turbid fluid. The habitual stirring-up of precipitates by chemists, to favor subsidence, need but be mentioned in this connection; as also the fact that troublesome powdery precipitates, such as oxalate of lime or molybdo-phosphate of ammonia, become flocculent when allowed to deposit on a sloping surface.

The presence of dissolved mineral matter greatly favors the coalescence of particles, and especially the precipitation of clay. Foremost among the active substances are lime and common salt;

the action of the latter being exemplified on the large scale, at the mouths of rivers, where the fine mud, whose molecular properties with pure water would have kept it in suspension for many days, is suddenly thrown down in the shape of mud shoals, in consequence of the admixture of sea water.*

The "settling" effect of alum, however, appears to be mainly due to the precipitation of alumina by the carbonates of lime and magnesia, present in almost all sediments.

The remarkable action of *lime*, in preventing diffusion and diminishing the plasticity of clay, will form the subject of a future communication.

NOTE.—The subjoined comparative analyses of one and the same material, after boiling 6^h and 30^h, respectively, exhibit the effect of thorough preliminary preparation, and the gross errors which may result from its neglect. It will be seen that while agreeing as closely as could be expected as regards the coarse materials, the differences in the percentages of the fine ones are so great as to render the first one absolutely nugatory, and calculated to lead to an utterly false estimate of the soil's qualities.

No. 173. Under-subsoil of Cretaceous prairie, Monroe Co., Miss. (See Miss. Rep., 1860, p. 262).

Time of boiling	6h.	30h.
> 64^{mm} h. v. (bog ore)	2·10	2·07
8–64 " " (siliceous sand)	0·62	0·55
8 " "	0·20	0·21
4 " "	1·26	1·21
2 " "	5·18	2·92
1 " "	6·30	7·36
$0{\cdot}5^{mm}$ "	13·19	8·81
$0{\cdot}25^{mm}$ "	27·93	7·85
< 0·25 " "	27·02	35·22
Clay,	14·82	33·16
	98·42	99·36

*This action of salt in clearing water has lately, it seems, been claimed as a new discovery by Mr. D. Robertson, in a communication to the British Geological Society. But the clearing of muddy water by salt, as well as by alum, has been a popular recipe for ages; and the action at the mouths of rivers is pointedly referred to by Mr. Sidell, in Rep. Phys. and Hydr. of Miss. River, App. A, p. xi.

SILT ANALYSES OF MISSISSIPPI SOILS AND SUBSOILS. BY EUGENE W. HILGARD, of Oxford, Mississippi.

THE results here communicated are the first-fruits of an investigation on the physical constituents of soils and clays, undertaken with the aid of the "churn elutriator" for silt analysis, described in another paper. While far from being as complete or satisfactory as I could desire, there is much that is suggestive of the direction to be pursued in the farther prosecution of the research, and of the importance of the results to be attained. The necessary interruption of the work on my part, for some time to come, may serve as an additional apology for an otherwise somewhat premature publication.

The materials of which the silt analyses are here given were chosen as typical representatives of the more important varieties of soils in the State of Mississippi. For reasons repeatedly explained, I have, in most cases, preferred to deal with the subsoil instead of the soil itself, whose organic ingredients materially interfere with the operations of analysis, as well as with the interpretation of the results. The general differences between the soil and subsoil, in ordinary cases, are well understood; and for general research and comparison, the latter is much more available. I have nevertheless, in one case, analyzed the soil and subsoil (206 and 209 of the table) for comparison; the differences falling, as will be seen, just where they would be expected. The deficiency in the summing up of the "*soil*" arises mainly, of course, from the dissolution and loss of vegetable matter.

As a standard for comparison and reference, I place first in the table a very pure, highly plastic pipe-clay; probably as free from foreign admixtures as a sedimentary clay can well be, the sediments being exclusively white quartz grains, sharp and angular. It resembles kaolin, and is probably directly derived from the carboniferous fire-clays.*

* Miss. Rep., 1860, p. 34 and ff.

SILT ANALYSES OF MISSISSIPPI SOILS AND SUBSOILS.

	DESIGNATION OF MATERIALS.	DIAMETER. (MILLIMETERS.)	VELOCITY (HYDR. V.). MILLIMETERS PER SECOND.	UPLAND. DRIFT.	YELLOW LOAM. SANDY.			LOAM.			TERTIARY. CLAY.				MISSISSIPPI BOTTOM. CHAMPLAIN. SWAMP.	RIVER.	MODERN. RIVER DEPOSIT.			DELTA.		VELOCITY (M M.).
				238 White Pipeclay. Tishomingo Co.	248 Tallahoma Subsoil. Jasper Co.	165 Lt. Flatwoods Soil. Chickasaw Co.	206 Pine Hill Soil. Smith Co.	209 Pine Hill Subsoil. Smith Co.	397 Oxford Subsoil. Lafayette Co.	219 Table Land Subsoil. Benton Co.	173 Prairie Subsoil. Monroe Co.	230 Hy. Flatwoods Soil. Pontotoc Co.	246 Red Hills Subsoil. Attala Co.	196 Hog Wallow Subsoil. Jasper Co.	390 Buckshot Soil. Issaquena Co.	237 Loess. Claiborne Co.	365 Tallahatchie Soil. Panola Co.	377 Frontland Subsoil. Sunflower Co.	395 Dogwood Ridge Soil. Coahoma Co.	Southwest Pass. Plaquemine Par.	Southwest Mudlump. Plaquemine Par.	
1	Coarse Grits	1.0 to 3.0			6.94	2.90	0.36	0.36		0.23	2.10	0.33	1.97	0.83	0.09	0.24	0.09					
2	Fine "	0.5 to 1.0			17.65	6.96	2.98	0.83				0.35		1.19	0.05							
3	Coarse Sand	80 to 90/180	64		18.81	2.81	6.62	6.21		1.47			0.72	1.96		0.37	0.04		0.15			64
4	Medium "	50 " 55 "	32	0.06	10.16	4.41	7.75	3.38	0.79	2.33	0.62		2.32	1.64	0.36	0.61	0.05	0.32		0.18	0.10	32
5	Fine "	25 " 30 "	16		2.66	3.13	3.01	3.85		1.17			2.09	0.88		0.93	0.21	2.97		0.47	5.02	16
6	Finest "	20 " 22 "	8	0.08	1.66	2.02	1.59	1.49	0.18	0.78	0.20	0.23	0.70	0.26	0.31	1.65	1.30	2.41	3.74	7.03	3.68	8
7	Dust "	12 " 14 "	4	0.02	1.02	2.23	1.19	0.64	0.78	0.76	1.26	0.18	1.29	0.10	0.27	1.95	2.68	16.90	21.49	12.38	5.34	4
8	Coarsest Silt	8 " 9 "	2	0.04	0.88	5.06	3.56	2.63	3.56	9.79	2.92	1.61	1.81	2.49	1.56	14.25	9.38	19.79	21.83	13.27	10.09	2
9	Coarse "	6 " 7 "	1	0.08	1.96	9.67	6.50	5.40	13.12	7.26	7.36	2.66	3.60	3.67	2.23	16.20	9.88	13.90	14.01	15.87	5.58	1
10	Medium "	4 " 5 "	0.5	0.08	7.89	14.18	13.97	7.77	16.64	13.14	8.81	9.13	2.73	5.39	3.68	20.08	20.37	4.27	9.93	8.25	9.54	0.5
11	Fine "	2.5 " 3 "	0.25	2.00	8.40	22.03	14.20	16.65	27.28	15.07	7.85	26.64	13.30	10.31	8.97	5.59	19.79	1.89	9.58	7.26	8.01	0.25
12	Finest "	0.1 " 2 "	<0.25	21.15	15.53	15.62	29.86	37.75	18.87	26.50	35.22	32.35	25.33	24.18	38.19	33.38	25.30	30.08	8.65	19.67	34.46	<0.25
13	Clay . . .	?	<0.0023	74.65	8.63	7.86	4.58	10.70	17.23	19.19	33.16	25.48	40.25	47.03	44.30	2.51	9.64	5.51	10.35	12.20	18.18	?
				98.16	99.28	98.68	95.67	97.77	98.35	97.65	99.50	97.87	96.11	100.00	100.01	97.74	98.73	98.04	99.72	96.58	100.00	
	Compactness (resistance to tillage)			97.80	32.56	45.33	48.14	45.10	63.38	60.82	69.77	84.47	78.88	81.52	89.46	41.48	54.63	37.48	28.57	39.13	60.65	
	Porosity			0.36	59.55	40.40	37.89	47.13	20.23	26.04	17.04	6.40	39.18	10.12	4.87	38.44	23.63	58.25	61.50	49.20	28.81	
	Hygroscopic Moisture (+7° to +21)			9.09	1.80	3.36	2.48	7.69	8.79	7.21	11.35	9.33	18.60	14.48	14.31	4.18	6.12	5.68	3.95			
	Ferric Oxid			0.13	1.10	(1.45)	1.25	4.15	2.53	5.11	5.42	(5.90)	10.50	4.00	(5.82)	3.27	2.58	2.31	2.60			

Of the "Upland" soils in the foregoing table, Nos. 248, 206, 209, 397, 219 and 173, are properly of the "Yellow Loam" age, *i. e.*, of the end of the Drift period;* while 165 is one of the two chief varieties of soils occurring in the "Flat Woods," a level area bordering on the Cretaceous, and mostly characterized by the occurrence of the lower tertiary clays near the surface. The *light* soil (165) occurs in irregular strips and patches; it is very easily tilled at all times; all rain water is promptly absorbed; but it is too "open," droughty, and does not hold manure at all.

No. 248 forms a stratum 3 feet thick, on the ridges east of Tallahoma creek, Jasper county, Miss. By its disintegration, it forms a deep and extremely sandy soil, which is injured by high winds carrying away its finer parts. It has, however, yielded good crops of corn and cotton for fifteen years without manure, though liable to injury from drought.—Nos. 206 and 209 are typical of the "Pine Hill" region of South Mississippi, the home of the long-leaved pine. The soil is very "light" and easily tilled, but not nearly as "open" as the preceding two. It is materially improved by the admixture of the subsoil, No. 209; which enables it to hold manure, being what would be termed a "sandy loam."

Nos. 397 and 219 are typical of the cotton uplands of western Mississippi and Tennessee; 219 being of the first quality; 397 a second-rate soil. Their prominent characteristic is an excessive and most distressing proneness to denudation or "washing," in consequence of a want of perviousness, together with the property of promptly swelling up, on contact with water, into a loosely gelatinous condition, in which they readily diffuse in water. From the same cause, the frequent alternations of freezes and thaws in the winters of their latitude of occurrence, are even more disastrous, and cause a frequent freezing out of winter grain, that at first sight seems very surprising. The effects of denudation on these soils are but too obvious even to the passer-by, are difficult to check, and are fast assuming the proportions of a public calamity.

These soils are easily tilled when in the proper condition, but if ploughed too wet are severely injured, hard clods remaining throughout the season. There readily forms on their surface a very hard crust (they "bake"), so that the surface requires stirring after every rain.

No. 173 is the subsoil of the cretaceous prairies of northeastern

* Miss. Rep., 1860, p. 197.

Mississippi, forming a stratum 3 to 7 feet thick, overlying the cretaceous rock. Although, in the wet condition, it is accounted a "heavy clay" soil, it possesses the peculiarity of "slaking" on drying, instead of forming a hard crust—unless, indeed, the drying process be exceedingly slow. It is not, therefore, as difficult to cultivate as would be supposed from the sum of its fine ingredients. Nor is it nearly as much subject to denudation as the two preceding soils, the mass formed by its contact with water being too tough and coherent to be readily moved by flowing water. But being very little pervious, it is liable to injury in wet seasons; while in dry ones, the cracks formed by the contraction of the subsoil prove disastrous.

No. 230 is the soil prevalent in the Flatwoods (see above), and is the direct result of the disintegration of the old tertiary clays. It is a very heavy, intractable soil, yielding good crops only in very favorable years, as it is exceedingly liable to injury both from wet and dry seasons, and can be tilled only within a very limited range of condition as to moisture. Water will stagnate on it for weeks, and a late, wet spring will, sometimes, altogether prevent the pitching of crops. But it is not at all liable to denudation.

No. 246 is likewise the direct result of the disintegration of (highly ferruginous) tertiary clays. Notwithstanding its high percentage of "clay," it is more easily tilled than the preceding one, although acquiring a stony hardness when dried slowly. The fact that among its 40·25 per cent. of "clay" there are 10·6 of ferric oxid, and that it contains ·8 per cent. of lime, explains both its easier tillage, and greater thriftiness, as compared with the preceding. It is a pretty "safe" soil, and quite productive; not at all subject to denudation.

No. 196 is the extreme of a clay soil, so as to be almost unfit for tillage, and directly available for the potter's lathe. It bears, nevertheless, a pretty good growth of timber, chiefly pine. Its popular name is derived from the peculiar aspect assumed by its surface, when after a drought which has caused fissures (as much as an inch wide) to be formed, a rain causes the edges first to crumble off into the open cracks, and then swell; which, with the subsequent swelling of the mass itself, compels it to bulge up. The result is a hillocky surface, which is popularly likened to "hog wallows." The soil is, at present, practically worthless.

The next, No. 390, is very similar in its (ostensible) physical

composition to the preceding. Yet while the "hog-wallow" soil is among the most worthless of the soils of Mississippi:— this, the celebrated "buckshot" soil of the Mississippi bottom, is among the most valuable. True, the chemical composition of the buckshot soil is greatly superior to that of the other; yet it could not rank as high as it does, as a cotton soil especially, but for the fact that (in common with the prairie soil, 173, above described) it possesses the property of crumbling or "slaking" by rapid drying; so that, even when it has been ploughed too wet, on drying, each clod resolves itself into a pile of loose crumbs, which have given rise to the popular name of "buckshot." Notwithstanding its clayeyness, it is therefore a very "safe" soil, and highly esteemed for its thriftiness.

Alongside of this soil, which represents the cypress swamp deposits of the "Port Hudson" epoch of the Champlain period of depression, I give the composition of the "Loess" of the Lower Mississippi; a deposit evidently formed in a shallow, broad, fresh-water estuary possessing a slight flow, during the time of more rapid depression of this portion of the continent. It forms a soil very easily tilled, somewhat too open and droughty, but fairly productive, and practically exempt from denudation.*

It is interesting to compare this ancient deposit with those now formed under somewhat analogous circumstances, by the sluggish "bayous" traversing the bottom of the great river. Compare No. 237 with 377, a "Frontland" soil from a plantation on Indian Bayou in Sunflower county, and we find the physical constituents almost identical. No. 395 is from a point near the main river, on Gov. Alcorn's plantation in Coahoma county; it has evidently been deposited by a more rapid current, as it contains more of the coarser ingredients, to which there adhered a sufficiency of clay to render the soil retentive, though so porous that water will not stand on it for a moment. It is very easily tilled, and from its great depth is very productive.

I subjoin for farther comparison, the analysis of a specimen of river deposit taken in the shallow water of the Southwest Pass of the Mississippi river, three miles below the Head of the Passes, at extreme low water. Here, again, the sediments of 1, 2, 4^{mm} form the prominent landmarks, as in the two other river deposit soils, in which the clay and finest silts seem to be the chief variables.

* Miss. Rep., 1860, p. 314.

Having thus established, presumably, the normal composition of the river alluvium proper, I add, for farther comparison, the analysis of material from a stratified mudlump cone, which greatly resembles in aspect the river deposit. The point to be determined is whether this cone represents an upheaved mass of river deposit, or the mud ejected from a mudlump crater* — an eruption cone. The result seems to point to the latter as the more probable origin of the mass, as it presents but little similarity to the recognized river deposits, in the proportions of its sediments.

In discussing the results of these analyses, I first recall to mind the practical object primarily intended to be subserved by them, viz., to convey to any intelligent mind, anywhere in the world, a definite idea of the physical qualities of the soil; of its tillability, so to speak; of its behavior in wet and dry seasons; its liability to washing, etc. If the data given in the table do not at present convey such definite knowledge to the minds of this audience, it is because the molecular properties of the several sediments are not yet fully known, nor generally understood. But there can be little difficulty in the empirical determination of these factors, once for all, so far as they refer to the pulverulent minerals, whose physical properties are sensibly dependent upon the size of the particles alone; the differences of specific gravity, etc., being ordinarily too slight to influence materially their modifying influence upon the clay, or upon each other. To this rule mica and bog ore form, probably, the only practically important exceptions.

As regards the modifying effect upon the extreme plastic properties of the clay, the pulverulent ingredients obviously divide into two chief classes, viz. —

1. The coarse portion, which increases the "lightness" and porosity of the soil, sensibly in proportion to its percentage.

2. The fine portion, which, while modifying the plastic properties of the clay, yet renders the soil heavier in tillage than would be the case if it were absent, and the clay adherent to the coarse particles alone.

Soils consisting mainly of very fine siliceous silt, with only a small percentage of clay, are among the very heaviest, working "like putty," clogging the plough when in the least degree too wet, and in drying, caking into clods of "hardpan."

* See my paper on the Geology of the Delta, and the Mudlumps of the Passes of the Mississippi, Am. Jour. Sci., April, May and June, 1871.

Such being the case, it would seem that between the coarse part which lightens soils, and the fine silts which, like clay, render them heavier, there must be a neutral point—a degree of fineness which will not sensibly influence either the porosity or the compactness of the soil. Odd as this conclusion appears, it seems nevertheless to be borne out by experience.

In fingering the coarser silts, it at once becomes obvious that nothing above 1^{mm} hydr. value can tend to render a soil heavier; while it is equally manifest that the impalpable particles belonging to the velocity of $0{\cdot}25^{mm}$ cannot tend to lighten. In searching tentatively, by the summation of groups of physical ingredients, for numbers that would satisfactorily express the estimated relative resistances to tillage of the soil analyzed, I found that such numbers would result from a summation of the three items lowest in the column, viz., the silts of 0·25, <0·25, and clay. These are given under the head of "Compactness" or "Resistance to Tillage."

Similarly, numbers satisfactorily expressing the relative "Openness" result from the summation of the coarser ingredients, down to 1^{mm} inclusive. These numbers are given opposite to the heading "Porosity."

But either series becomes quite unsatisfactory, so soon as the silt corresponding to $0{\cdot}5^{mm}$ is added either way; except, of course, where its percentage is too small to influence either sum very seriously.

Of course these can only be approximations, it being especially obvious that sand of 64 and 32^{mm} must exert a much greater influence towards rendering a soil "open," than silts of 1 or 2^{mm}; which are, nevertheless, accounted for as equal in effect, in the above summation. Yet even here, there are counterbalancing considerations, which in a measure explain the comparatively close approximation to the result of experience. Chief amongst these is, doubtless, the circumstance that the finer materials, when damp and stirred up (as they are in the cultivated soil), will occupy a much greater bulk than equal weights of coarse sand; being in what is technically termed a "woolly" condition of looseness. It is therefore quite intelligible that, within certain limits, "coarse silt" should exert a "lightening" influence equal to that of "coarse sand," which is apt to pack quite closely.

It may be asked, What would be the character of a soil consist-

ing exclusively of the silt of $0{\cdot}5^{mm}$, claimed to be sensibly neutral in its effect on the compactness and porosity of soils? I reply that, judging from the small quantities of material at my command, such soil would offer an extremely slight resistance to tillage, and that such resistance would be increased by the addition of either clay or sand, in proportion to the amounts added.

The case, however, can hardly occur in nature. The difficulties encountered in separating the several materials in accordance with their hydraulic values, even by the aid of apparatus especially constructed for the purpose, forcibly suggest that it is scarcely possible that such conditions should ever be realized in nature: the tendency to coalescence of particles necessarily causing all sedimentary deposits to consist of molecular aggregates (at least so far as the finer portions are concerned), instead of simple granules. These aggregates will rarely, if ever, consist of particles of equal hydraulic value, the natural tendency being for small particles to fill up the interstices left between larger ones, which cannot attain close contact between themselves alone.* Moreover, in view of this inevitable formation of aggregates, the molecular properties of a clay or subsoil will never correspond exactly to the mean resulting from a mere consideration of the molecular coëfficients of each one, multiplied into its percentage. How far this difference extends, is a question involving a previous investigation of those coëfficients.

Among the latter, that of absorption of aqueous vapor is of no mean importance, since it determines, in a great measure, the resistance of the soil to drought. As heretofore stated,† I find that at temperatures between $+7$ and $+21°$, the amount of aqueous vapor absorbed by a thin layer of a clay, or soil not unusually *rich in humus*, in a saturated atmosphere, is sensibly constant; the variations being within the limits of errors of observation, and indiscriminately either way. A glance at the data given in the table, opposite the heading "hygroscopic moisture," shows that while in general, as is well known, clay soils are more absorbent than sandy ones, yet there exists no direct numerical relation between the amount of clay present, and the absorbing power. Not

* There is a sensible difference, in this respect, between materials much rounded and water-worn, and those whose grains are still "sharp." The latter are much more difficult to separate in the churn elutriator, and re-coalesce most pertinaciously.

† Proc. A. A. A. S., Dubuque meeting, 1872; p. 78.

only is that of the typical white pipe-clay (No. 238) scarcely greater than that of an ordinary loam subsoil (Nos. 397 and 219), but it is not half as great as that of the clay soil 246 (with 40 per cent. of "clay") which in its turn has a higher absorptive coëfficient than 196 (with 47 per cent. of clay). Finally, 230, with 25·5 per cent. of clay, is more than equal in hygroscopic power to the pipe-clay with 75 per cent.

Evidently, the hygroscopic coëfficient is largely controlled by the presence, with the clay, of the powdery ingredients which determine its looseness of texture, so to speak; moreover, the finer silts themselves possess a considerable absorbing power. Again, the presence of hydrated ferric oxid materially influences this power; so much so that no general conclusion concerning the hygroscopic effect of "clay" can be reached, unless the amount of iron present be taken into account. I am unable, as yet, to furnish this datum for all the soils on the table, save as regards, for most of them, the percentage in the original substance. That the hydro-ferric oxid accumulates mainly in the "clay" obtained in silt analysis, I have already stated; and hence the percentages given at the bottom of the table may measurably serve to form an estimate of its influence on the hygroscopic properties. In some cases, however, the ferric oxid obtained in analysis was almost altogether present in the shape of bog-ore grains; these are placed in parentheses, it being obvious that the "white" soils, to which these determinations belong, do not contain more than 0·5 per cent., of the oxid in the finely divided, hygroscopically effective condition. In the coarse sandy soil 248, the iron mainly incrusts the sand grains; and in Nos. 165, 206 and 390, the presence of humus, in sensible quantities, influences the coëfficient. In the rest, the amount of humus is insignificant, and the influence of the finely divided hydro-ferric oxid is especially noticeable when we compare Nos. 209 and 397 with each other; and also Nos. 230 and 196 with 246. The clay obtained in the silt analysis of No. 219 contains, according to Mr. Loughridge's determination,* 18·76 per cent. of ferric oxid, as compared with 5·60 in the original substance; its absorptive coëfficient was 20·0, as compared with 7·21 in the original. How much of this increase of hygroscopic power was due to the concentration of the clay alone, we can at present but conjecture; but if we may judge by the

* See the succeeding paper.

absorptive power of the pipe-clay 238, the increase must be largely attributed to the hydro-ferric oxid.

The influence of "humus" on the hygroscopic power is known to be very great; so also is that on the soil's porosity and resistance to tillage. Unfortunately, the very indefinite character of that substance renders it extremely difficult to determine quantitatively its action, and take it into account.

The questions remaining to be determined in connection with this whole subject are so numerous, and so little explored as yet, that their full elucidation might well form the work of a lifetime.

ON THE DISTRIBUTION OF SOIL INGREDIENTS AMONG THE SEDIMENTS OBTAINED IN SILT ANALYSIS. By R. H. LOUGHRIDGE, of Oxford, Miss.

IN connection with the separation of soils into sediments of definite hydraulic value, as accomplished by Dr. Hilgard's churn elutriator, an interesting question arises as to the chemical composition of the sediments obtained.

It is evident from his results that, in the soils treated, all of the important soil ingredients are contained in the finer sediments, there being visibly nothing but quartz sand of different diameters remaining in the coarser ones.

Does then the "Clay" contain them all, or are they more or less distributed among the several proximate sediments?

In the investigation of this question, use was made of the same yellow loam upland subsoil, from Benton Co., Miss., that formed the subject of my experiments on "Strength of Acid and Time of Digestion." Great care was taken to obtain a complete and pure sedimentation, distilled water being used; and the analyses were made, according to our usual method, after five days' digestion in acid of strength 1·115.

In the following table of results the percentages are given, first with reference to the absolute amount of each sediment itself; then with reference to the entire amount of soil taken for elutri-

ation. In the last column a summation is made of each ingredient for comparison with a previous analysis of the soil, which is placed alongside.

Hydraulic Value . .	CLAY		<0.25mm		0.25mm		0.5mm		1.0mm		Other Sediments.	Total in Sediments.	Original Soil.
Per Cent. in Soil . .	21.64		23.56		12.54		13.67		13.11				
	A	B	A	B	A	B	A	B	A	B			
Insoluble Residue	15.96	4.35	73.17	17.29	87.96	11.03	94.13	12.72	96.52	12.74	13.76	71.89	70.53
Soluble Silica . .	33.10	7.17	9.95	2.34	4.27	.53	2.35	.32				10.36	12.30
Potash	1.47	.32	.53	.12	.29	.04	.12	.01				.49	.63
Soda	(1.70)		.24	.06	.28	.04	.21	.02				.12	.09
Lime	.09	.03	.13	.03	.18	.02	.09	.01				.09	.27
Magnesia . . .	1.33	.29	.46	.11	.26	.03	.10	.01				.44	.45
Br. Ox. Manganese	.30	.06	.00	.00	.00	.00	.00	.00		0.36		.06	.06
Ferric Oxid . .	18.76	4.06	4.76	1.11	2.34	.29	1.03	.14				5.60	5.11
Alumina . . .	18.19	3.97	4.32	1.04	2.64	.33	1.21	.17				5.51	8.09
Phosphoric Acid.	.18	.04	.11	.02	.03	.00	.02	.00				.06	.21
Sulphuric Acid .	.06	.01	.02	.01	.03	.00	.03	.00				.02	.02
Volatile Matter .	9.00	1.33	5.61	1.43	1.72	.23	.92	.29				3.64	3.14
TOTAL . .	100.14	21.64	99.30	23.56	100.00	12.54	100.21	13.67		13.10		98.28	100.63
Total Soluble Matter	75.18		20.52		10.32		5.16						
" " Bases.	41.84		10.44		5.99		2.76						
Soluble Silica in Crude Substance	.38	0.01											0.19

A. Calculated on the amount of Sediment. B. Calculated on the amount of Soil.

It appears from these analyses that the "clay" is by far the richest in mineral ingredients, the amount being more than twice that of the others combined. Its insoluble residue is very small, while the soluble portion consists largely of free silica derived from hydrous silicates of the bases.

Its volatile matter (which includes hygroscopic moisture left after drying at 100° C., and water of hydration) is of course the largest; as are also the remaining ingredients, except lime. The

large amount of soda, however, is due to the chloride used in the precipitation of the diffused clay.

In the other sediments, the soluble ingredients, except soda and lime, decrease in almost a geometrical ratio; there being also a corresponding increase of sand.

There are several interesting points in connection with this ratio of decrease which may be summed up as follows.

1. The iron and alumina exist in almost identical relative proportions in each sediment; making it probable that they are in some way definitely correlated.

2. Potash and magnesia also exist in almost the same quantities, and their ratio to each other in all the sediments being almost constant seems to indicate that they occur combined, perhaps in some zeolitic silicate, which may be a source of supply to plants.

3. Manganese exists only in the clay, a mere trace being found in the next sediment.

4. The lime appears to be "nowhere," having probably been largely dissolved, in the shape of carbonate, by the large quantity of water used in elutriation. Its increase in the coarser portions may be owing to its existence in the crystallized form, not so readily soluble.

In a general summation of the ingredients in the several sediments and comparison with the analysis of the soil *per se*, there is a loss in potash, magnesia and lime; which may reasonably be supposed to have been dissolved by the water of elutriation.

Some of the soluble silica clearly remains undetermined in the coarser sediments.

The differences in ferric oxid and alumina, shown throughout the analyses of this soil, may partly be accounted for by the unequal distribution of the particles of iron ore existing in the soil.

Of course the law of distribution of soil ingredients may differ in other soils; but the great distance from the point of derivation of the materials, and the wide distribution of the soils of which this is a type, probably render the above results of more than local applicability.

ON THE INFLUENCE OF STRENGTH OF ACID AND TIME OF DIGESTION IN THE EXTRACTION OF SOILS. By R. H. LOUGHRIDGE, of Oxford, Miss.

THE following investigation was undertaken with a view of determining the extent to which the variations likely to occur in the extraction of soils by hydrochloric acid, for the purpose of analysis, can influence the ultimate results; the special object being to ascertain the comparability of the analyses made in connection with the Agricultural Survey of Mississippi, both amongst themselves, and with those made by similar methods, by Dr. Peter, of soils collected by the Surveys of Kentucky and Arkansas.

In beginning the analyses of Mississippi soils in 1858, Dr. Hilgard adopted the following method, which has also been adhered to by his successors in this work, in over two hundred analyses made.

The soil (*i. e.* "fine earth") is pulverized with a wooden pestle and thoroughly mixed. The hygroscopic moisture is determined, after exposing it in a space saturated with vapor, in a layer not exceeding 1^{mm} in thickness, for twelve hours, by drying at 200° C. in a paraffine bath. Of this dried substance from two to three grams are usually used in the general analysis, the methods employed being in general those adopted by Dr. Peter.* In another portion, after ignition, the phosphoric acid is determined by digestion for five days with nitric acid at 100° C., evaporation, precipitation by ammonium molybdate, digestion at 100,° solution in ammonia and precipitation by magnesium sulphate.

For general analysis the soil is digested in hydrochloric acid of strength 1·115 (as a rule) at 100.° It is then evaporated to complete dryness, this adding another day to the digestion.

In the insoluble residue the soluble silica is determined by boiling with sodic carbonate. The alumina and ferric oxid are precipitated according to Rose's method of boiling, for the complete separation of manganese, magnesium and calcium. The mixed precipitate is treated with potassic hydrate.

After precipitation of the lime by ammonic oxalate, the ammoniacal salts are destroyed by Lawrence Smith's method, with aqua regia; and the residue converted into nitrates, from which

*Ky. Report, vol. iii.

sulphuric acid is precipitated by barium nitrate. The alkalies are then separated by treatment with oxalic acid, ignition and washing. In the residue, barium, manganese and magnesia are separated as usual.

With the aid of a Bunsen's filtering apparatus we can, by this method, complete an analysis in five days exclusive of digestion; and three analyses may be in progress at the same time.

The substance experimented upon was a subsoil, a typical representative of the best yellow loam uplands of Mississippi, from the table lands of Benton Co., Miss.; No. 219 of the Survey Collection.*

To determine the question as to whether such variations in the strength of the acid, as might possibly have occurred in the use of the steam-distilled (*i. e.* from a retort surrounded by steam) product, without previously ascertaining its concentration, portions of the subsoil were digested five days with hydrochloric acid of the strength, severally, of 1·100, 1·115 (the normal concentration) and 1·160.

As to the time during which the soil must be digested in hydrochloric acid that the (sensible) limit of its solvent action upon the important soil ingredients may be reached, Dr. Peter's practice has been to digest for about ten days, in his 800 analyses of Kentucky and Arkansas soils; while for reasons of convenience, half that time has been adopted in the analyses of the Mississippi Survey. The question whether under these circumstances, the two series can be deemed comparable, was approached by digestions for periods of one, three, four, five and ten days, of the same soil with the same large excess of acid of 1·115; all precautions being taken to accomplish each analysis as nearly as possible under the same circumstances.

For the digestions, use was made of porcelain beakers (the use of glass being objectionable because of its solubility); the same amounts ($40^{ccm.}$) of acid were used, and steam kept up about twelve hours each day.

The hour of "putting down" was carefully noted, and at the end of the allotted time the solution was poured off from the insoluble residue, and each evaporated to dryness separately and reunited in solution, to prevent any further action of the acid.

*The Analysis of the subsoil of a neighboring tract is given in Hilgard's Report, 1860, p. 292.

The results of the investigation as to strength of acid are as follows:—

INGREDIENTS.	SP. G. OF ACID. 1.10	1.115	1.160
Insoluble Residue . . .	71.88	70.53	74.15
Soluble Silica	11.38	12.30	9.42
Potash	.60	.63	.48
Soda	.13	.09	.35
Lime	.27	.27	.23
Magnesia	.45	.45	.45
Br. Ox. Manganese . . .	.06	.06	.06
Ferric Oxid	5.15	5.11	5.04
Alumina	6.84	8.09	6.22
Sulphuric Acid	.02	.02	.02
Volatile Matter	3.14	3.14	3.14
	100.02	100.69	99.29
Amt. of Soluble Matter .	24.00	27.02	22.27
Amt. of Soluble Bases . .	13.50	14.70	12.83

It thus appears that in the strongest acid the amount of insoluble residue is far greater than in either of the others, and that the difference lies chiefly in the soluble silica and alumina (*i. e.* clay), together with potash and lime. The other ingredients seem to be indifferent as to the strength of the acid.

Between the acids of strength 1·10 and 1·115 the difference is not so great, but the advantage is clearly with the latter, the amounts of silica, potash and alumina being greater, while the lime remains the same in both.

This result points to the conclusion, that while lime and magnesia (being readily dissolved) are probably present chiefly as carbonates or hydrocarbonates: potash as well as alumina, and to some extent lime, are present as silicates, and for that reason are not as fully extracted by acid of low strength as by that of 1·115; although the former acts more powerfully than that of 1·160.

The latter fact (the coincident result of two analyses), though

unlooked for, is not without analogies, although its precise cause, in this case, still requires elucidation. Whether the maximum of action is exerted by acid of 1·115 is another question of some interest, to be determined hereafter.

As for the comparability of the analyses as affected by the probable variations of strength of acid, I remark that the acid used for distillation by Dr. Peter, as Dr. Hilgard informs me, was the "C. P." of commerce, whose strength rarely much exceeds or falls below that of 1·115; while that used by us was usually the crude, diluted nearly to the same strength. The first and last portions coming over were habitually, I believe, rejected in either laboratory. Under these circumstances, it is very improbable that either of the extremes of sp. gr., above discussed, ever actually occurred; especially as regards the stronger acid, which being in small quantity, would always be mixed with the succeeding weaker distillates.

It is therefore not probable that the percentage of potash, or other important ingredients, could have been so far underestimated in either of the series of analyses, as seriously to influence their comparability, either within themselves, or with each other.

The experiments on the influence of the time of digestion, made with acid of 1·115, resulted as shown in the table opposite.

It appears that the amount of dissolved ingredients increases up to the fifth day, the increase becoming, however, very slow as that limit is approached. It is also found that the ingredients offering the greatest resistance to this action are the same as those whose amounts were sensibly affected by the strength of acid, viz., silica, potash and alumina.*

In regard to lime and magnesia, one day's digestion not being sufficient for full extraction, it is evident that they do not exist in the soil as carbonates or hydric oxides only, as has been supposed; but also as silicates.

A comparison of the results of the five and ten day digestions shows that the solvent action of the acid has substantially ceased, there being no further increase of the amount of dissolved matter.

* There is an apparent loss of alumina in the 4 days' digestion, owing to the lack of a second separation from iron, whose quantity is correspondingly increased.

So far, therefore, as the time of digestion is concerned, the analyses of the Mississippi Survey are strictly comparable with those of Arkansas and Kentucky soils, made by Dr. Peter.

INGREDIENTS.	No. of Days Digested.				
	1	3	4	5	10
Insoluble Residue . . .	76.97	72.66	71.86	70.53	71.79
Soluble Silica	8.60	11.18	11.64	12.30	10.96
Potash	.35	.44	.57	.63	.62
Soda	.06	.06	.03	.09	.28
Lime	.26	.29	.28	.27	.27
Magnesia	.42	.44	.47	.45	.44
Br. Ox. Manganese . .	.04	.06	.06	06	.06
Ferric Oxid	4.77	5.01	5.43	5.11	4.85
Alumina	5.15	7.38	7.07	7.88	7.16
Phosphoric Acid . . .				.21	.21
Sulphuric Acid	.02	.02	.02	.02	.02
Volatile Matter	3.14	3.14	3.14	3.14	3.14
TOTAL	99.63	100.68	100.55	100.69	99.80
Amount of Soluble Matter	19.67	24.88	25.57	27.02	24.87
" " " Bases.	11.05	13.68	13.91	14.49	13.68

REMARKS ON GLASS-MAKING. By LEWIS FEUCHTWANGER, of New York, N. Y.

CONSIDERING the incalculable benefits which the discovery of glass has rendered to mankind, not alone for purposes of daily life as an article of domestic use but, I may say, for more important and higher objects, as by the knowledge of glass and its applications the most accurate observations and experiments in astronomy, natural philosophy, chemistry and physiology have been performed, we have nevertheless been very slow in keeping pace with the discoveries and improvements in other kindred arts and sciences. While Pliny and Strabo gave at an early period very accurate accounts of the glass manufacture in Alexandria and even the Portland vase, which was the most beautiful specimen of colored antique glass and was found in a marble sarcophagus, within the tomb of Alexander Severus, who died in the year 235; we have only the full description of the art of glass-making from Agricola in 1550, and have the information of the first glass-house in England in the year 1557 and that in Sweden in 1641; still very few improvements have been brought to light; the same furnaces, the same tools, the same materials and the same glory-hole have been to this day retained these 320 years; if we except the application of Siemen's Furnaces, which are intended to save the heat of the gas, which is not taken up in the reduction of the glass materials, while the chamber under each end of the furnace is so arranged that the outer one receives the air and the middle one mixes and ignites air and gas, whereby the heat is saved at a very great percentage so as to calculate one pound of glass from one pound of coal.

The discovery of LeBlanc in 1792, which is the conversion of common salt into carbonate of soda, is another improvement of the eighteenth century. The application of glass for optical purposes such as microscopes, telescopes, cameras, etc., has for fifty years past occupied the unceasing attention of the greatest philosophers of the nineteenth century without fully overcoming the many obstacles; it arises from the power which glass possesses of refracting light or turning it aside from its original direction; the property of decomposing white light and giving rise to colors; for an instrument constructed with lead glass lenses will produce an

image of the heavenly bodies or of microscopic objects with a colored margin, which will preclude the possibility of accurate observation. The experiments of Faraday, Frauenhofer, Utzschneider, Guinand and Bontemps have been met with many difficulties in producing an achromatic lens, for the simple reason that the refractory power depends upon the different density of materials, and a want of uniformity in the refractive power of the glass in different parts of the mass, and whenever a denser layer of glass comes in contact with one of less dense matter a streak is produced which will occasion distorted images.

In 1827, while a student in Jena, I assisted my teacher, Koerner, in numerous experiments of glass-making, principally for obtaining achromatic glass of uniform density, by the use of caustic baryta, borax, and silex, all materials very carefully prepared for the furnace, keeping the mixture in fusion for six days and allowing it to cool slowly for six days more before removing the pot, and then to break the same so as to use the lowest part of the mass for cutting up into lenses; we succeeded but partially. Faraday's report in 1830 speaks of his borosilicate of lead which yielded him a heavy glass of 5·4 specific gravity with a low dispersive power; still it did not prove useful for optical purposes and was altogether unfit for the desired object.

In order to obtain an achromatic glass of a fair standard, the manufacturers have of late years resorted to the expedient of combining one kind of glass, which is called crown glass, and composed of silex, potash and lime, with another glass called flint glass, which contains an addition of sixty per cent. of oxide of lead, a combination which would be satisfactory as regards the refracting power, but the difference of specific gravity through the whole mass has again produced the obstacle; this had to be overcome by uniting numerous and small selected masses of glass of well ascertained gravity which must be quite uniform, into one large mass, while still plastic by pressure. It is clearly shown that flint glass decomposes light more distinctly, as regards the refracting power, than crown glass, which contains no lead; and by employing a concave lens of lead glass and a convex lens of crown glass, when combined their respective effects upon light will compensate each other in consequence of the forces of the compound lens.

Now all these remarks prove how deficient the art of glass-making is to this day, both in the production of achromatic glass as well as

in that of a proper and uniform composition. The glass-maker has not yet appreciated the atomic theory, which would teach him that certain equivalents are necessary for the production of uniform mass; he is behind the art of steel manufacture, for which the spectrum gives him the sign when his ingredients are chemically combined.

Description of a Printing Thermometer. By G. W. Hough, of Albany, New York.

During the past quarter of a century numerous mechanisms have been constructed for recording automatically the fluctuations of temperature. The machines heretofore used for this purpose may be divided into three classes:—

First,—Records made by a metallic thermometer by using either a single wire or a combination of rods.

Second,—The application of photography, by means of which the height of the mercury in the thermometer tube is photographed in the form of a continuous curve.

Third,—Records made at definite intervals from a mercury thermometer by the use of electro-magnetism.

The first method is capable of giving approximate results. There are, however, serious objections to its use, the most important of which is the impossibility of making a piece of metal subjected to any work maintain its zero of length. To illustrate:—if a rod of brass or steel be made to support a weight, viz., ten pounds and at the same time be subjected to heat and cold, for a short time, the length of the bar at a given temperature will not be the same as previous to the experiment, consequently metallic thermometers will not maintain a fixed zero; a fact observed by many meteorologists.

Another objection to the method of mechanical registration is that when a machine is made to do work, its indications are not always the same. The force required to make a legible mark seriously interferes with the accuracy of its results.

Of the second method, by means of photography, it may only

be necessary to state that the amount of attention required in the preparation of the paper, the developing of the photographs and the measuring up of the records, precludes the possibility of its general use by meteorologists. The records also are often indistinct, and the curve is never sharp, showing that all minute fluctuations are lost.

Of the third form of instruments, when the record is made at definite intervals by means of electro-magnetism, the zero of the thermometer, if of mercury, will remain fixed and the records will be correct within certain determinate limits. The only objection is, that changes occurring between the intervals of recording are not shown; with this exception, the method may be regarded for general use as superior to those before mentioned. A thermometer constructed on this plan has been in operation at the Dudley Observatory for the past three years. But the labor required for converting the curve into numerical results was so great, that it was decided to construct a machine that would give the height of the thermometer hourly, printed with type.

The thermometer which we have adopted, consists of a glass tube bent in the form of a siphon, the closed leg of which is filled with alcohol and the open one with mercury. On the surface of the mercury in the open end, there rests an ivory float suspended from a delicate balance, having platinum wires attached to each end of the lever; when the column of mercury in the thermometer tube rises or falls from the effect of temperature, the platinum wires dip in small mercury cups placed underneath them, thereby causing a current of electricity to pass through one of two electro-magnets operating mechanism for giving motion to a fine micrometer screw. The motion of this screw elevates or lowers the carriage supporting the balance, thereby breaking the circuit.

Whenever a change of temperature equal to one-tenth of a degree Fahrenheit occurs, the magnetic circuit is completed and the screw is moved a space equivalent to the change in the height of the mercury in the thermometer. By this method, which is the same in principle as our printing barometer described in 1866, no work is required to be done by the thermometer, with the exception of supporting one-half the weight of the float. The force required to establish a magnetic current does not exceed two grains, and when once established even this pressure on the mercury column is removed.

When the temperature rises or falls the screw follows its motion, at the same time the clock-work moves the type wheels, indicating the temperature, which is printed at the end of each hour on a slip of paper moving in front of them. A pencil held against a revolving drum also records a continuous curve, exhibiting at a glance the height of the thermometer.

The machine gives the temperature to tenths of degrees; the probable error of an impression being about two-tenths of a degree Fahrenheit. The clock-work and printing mechanism are placed inside the building; the thermometer and carriage only being outside. The connection between them is made by a fine wire running over two pulleys and attached to the micrometer screw and balance.

Description of an Automatic Registering and Printing Evaporator and Rain Gauge. By G. W. Hough, of Albany, New York.

One of the most important elements in the study of meteorological phenomena has heretofore been too much neglected. We refer to the evaporation continually taking place on the earth's surface.

But comparatively few observations have been made to determine the amount of water evaporated at different places and for different conditions of the surface. Engineers, in estimating the water supply for cities, have, until perhaps quite recently, based their estimates entirely on the amount of rainfall, a very fallacious method, since it will be apparent to any one, on reflection, that for two localities of equal area and similar surface, the one covered with forest and the other exposing the ground uncovered, the amount of water which can be utilized will be much greater in the former case than in the latter. What ought to be ascertained, therefore, with the greatest precision possible, is the amount of the evaporation in forests and in the open country, as well as for different conditions of the soil.

Although the rainfall has not sensibly changed in amount since the first settlement of this continent, yet it is well known that the

volume of water in the brooks and small streams has greatly diminished. One need only make a journey through the older states and notice the ruins of former mills to be forcibly reminded of the fact. We recall to mind a number of instances of brooks, which in our boyhood were considerable streams for the whole season, and are now entirely dry during the greater part of the year.

The amount of water annually reaching the ocean through our great rivers may not have sensibly diminished, yet owing to the gradual removal of the forests they become more and more subject to excessive fluctuations in volume, owing to the ease with which the rain-water, falling on an uncovered surface, reaches their channels.

The agricultural condition of the country, too, depends largely on the amount of evaporation. A record of the rainfall alone is not sufficient to determine whether the conditions for agriculture were favorable or otherwise. It is only when the two elements, rainfall and evaporation, are considered together, that correct conclusions can be reached.

The importance of the subject led us to devise a mechanism for recording continuously, in the form of a curve, the amount of rainfall and evaporation, and for printing hourly, to the one five-hundredth of an inch, the same quantities.

The discussion of such records would enable us to determine the diurnal variation of these elements, heretofore but approximately known.

In order to record the fall of snow, and the evaporation from snow or ice in the winter season, without changing the apparatus or mode of registration, it was decided to record by weight instead of volume, as is usually the practice.

The apparatus consists of a vessel two feet square and one foot deep, suspended by means of one or more levers, and held in equilibrium by a small spring balance. The amount of change in weight of the mass, either that due to the precipitation or evaporation, will then be indicated on the balance.

It is obvious therefore, that were a pencil connected with the end of the weighing lever, it would trace, on a suitable revolving drum, the changes of weight. But such a crude device would not give results sufficiently accurate for ascertaining the hourly evaporation. If, however, in place of making the apparatus do mechanical work directly, the lever is made to vibrate between two platinum points,

whenever a change equivalent to the weight of one five-hundredth of an inch of water takes place, it will touch one of the points, thereby establishing a circuit through one of two electro-magnets, operating a micrometer screw; since the force required to complete an electrical circuit between two plates of platinum amounts to only a few grains, it is seen that no sensible amount of work is required of the apparatus.

This mechanism is now in process of construction; when completed, the vessel for holding the water will be placed on the roof of the Physical Observatory with the recording apparatus inside; the connection between the two being secured by means of a small wire cord. It will be exposed directly to the sun and wind, and will give results from which may be determined the coëfficients of temperature, wind, moisture, etc., affecting the rate of evaporation.

The amount of evaporation from soil can be ascertained by filling a suitable vessel with soil saturated with water, and recording the weight either continuously or at definite intervals.

On the Introduction of the Metric System into Medicine and the Unification of Doses. By Harvey W. Wiley, of Indianapolis, Indiana.

In Chemistry, the basis of pharmacy, the work of introducing the Metric System is accomplished. The first step, therefore, is already taken, affording a stronger reason for the completion of the work.

There is certainly no great propriety in buying a kilogram of potassic bromide, and then dealing it out to our patients in grains and drachms. But because our physicians and druggists are used to grains and minims, drachms and fluid ounces, these values must be used as aids to something better.

For practical purposes we may take the gram as equal to 15·5 grains. It is easy thus to change grain or multiple grain doses into the Metric scale.

Thus ·1 gram is equal to a grain and a half, so that those medicines which are now given in from 1 to 2 grain doses might readily be prescribed in doses of ·1 gram.

Continuing the comparison, we find :—

3	grains	=	·2	gram.
4·5	"	=	·3	"
6	"	=	·4	"
7·5	"	=	·5	"
9	"	=	·6	"
10·5	"	=	·7	"
12	"	=	·8	"
13·5	"	=	·9	"
15	"	=	1	" nearly.

Of course these are only given as approximate values, and they will aid us in estimating how many grams, or what part of a gram of any medicine, should be administered, by a knowledge of the number of grains which we have been in the habit of exhibiting. After we have become familiar with the gram quantities, we need no longer think of the grains; just as one who has a thorough knowledge of a foreign language does not translate it into his vernacular when reading.

In regard to those medicines which are administered in a liquid form, we can make similar comparisons, subject to similar explanations. Thus 16·2318 minims = 1 cubic centimetre, or 1 millilitre.

Practically therefore :—

4	Minims	=	·25	Centimetre^3	
8	"	=	·5	"	
12	"	=	·75	"	
15	"	=	1	"	
20	"	=	1·25	"	
24	"	=	1·5	"	
28	"	=	1·75	"	
32	"	=	2	"	= half a teaspoonful.
36	"	=	2·25	"	
40	"	=	2·5	"	
44	"	=	2·75	"	
48	"	=	3	"	
52	"	=	3·25	"	
56	"	=	3·5	"	
60	"	=	3·75	"	
64	"	=	4	"	= teaspoonful = fluid

drachm nearly = 60 drops.

Let it be remembered, however, that the drop is as variable as the old system of measures, for while about 50 drops of dilute sulphuric acid are equal to $4cm^3$, it requires 120 of laudanum and 150 of ether to make the same amount. But the size of the drop depends also upon the shape and size of the orifice through which it comes.

These tables of comparisons might be continued to exhibit larger or smaller quantities; but, just as they are, they apply to the greater number of medicines administered.

If it be objected that druggists would not know how to fill a prescription in which grams and cm^3s were employed, it is sufficient to say that they could easily learn; and any intelligent physician or apothecary in half an hour could thoroughly master the Metric System and begin to write and fill prescriptions in its symbols to his almost unlimited advantage.

I have, however, as the principal object of this paper and the especial purpose for which its preparation was attempted, to submit a further suggestion to the profession touching the introduction of the Metric System in medicine. It is a plan for the *Unification of Doses.*

Every practising physician is painfully aware of the fact that mistakes are daily made in the compounding and division of medicines which frequently end in most disastrous results, and, unless the physician himself has an extraordinary memory, it is most difficult for him to keep in mind the proper amount, of any but common remedies, which ought to be administered.

Especially is this true of young physicians where the memory is not fortified by long experience. The young physician may easily make out his diagnosis and recall the remedy which is most appropriate, but among the thousand different quantities which constitute a dose, he cannot recall that one which belongs to the remedy he wishes to use. He, therefore, either has to postpone its exhibition or guess at the quantity to be given; in either case at a great risk. Moreover, every medical student knows that by far the most difficult part of the *Materia Medica* is that which relates to quantity. He can remember the source of the drug, the method of its preparation, its therapeutic action, its compatibles and incompatibles; but, when he comes to the proper amount for a dose, his memory fails him at the very point where practically he needs it most. It therefore seems evident, that if any system can

be devised by which the great majority of remedies in common use could be made to have a common quantity for a dose, the physician, the apothecary and the patient would all be benefited.

In order that this happy pharmaceutical millennium may be brought about, it is necessary in the first place to establish at least two standard doses, one for solids and one for liquids. This being done, in the second place it will be necessary to have all solid substances so prepared that the standard dose will be the average dose of that solid for the adult patient.

In like manner the liquid medicine should be prepared so that the standard dose would as before be the average for the adult patient.

Let us now fix these standard doses as follows. (This is only a suggestion in regard to the standard doses; it could be fixed at any other value if found more convenient. It, however, fully illustrates the *principle.*) For a solid let the standard be ·2 gram. This is about 3 grains. Let quinine be taken as the typical solid. It is a *normal* solid. By this is meant that the standard dose, ·2 gram, is the average dose for the adult patient.

A prescription for quinine would therefore read

℞ Quiniæ sulphatis, grams ij (N).

Sig. one every two hours till cinchonism is produced.

(N) signifies that the solid is *normal*, *i. e.*, the dose is ·2 gram or three grains. This signifies that the apothecary is to put the two grams up in ·2 gram powders. Therefore it is not necessary to rewrite it on the prescription. Suppose however the physician should desire to prescribe powdered opium. In this case of course the standard dose would be too large. It would be rather unsafe practice to exhibit ·2 gram opium to a patient unaccustomed to its use. In order to meet this, and similar difficulties in solids and liquids, all manufacturing chemists should be required by law to make only standard mixtures and solutions or some multiple of the standard. Thus powdered opium thoroughly rubbed up with three times its weight of milk sugar, chalk or some other comparatively inert substance would become a normal mixture and should be put up in a bottle labelled (N). The physician would therefore write

℞ Opii pulveris gram j (N).

Sig. one at night before bedtime (etc.).

Morphia on the other hand should be most thoroughly tritu-

rated with seventeen times its weight of equal parts of milk sugar and chalk, in order to form a normal mixture; we could then write

℞ Morphiæ sulphatis, gram, ij (N).

Sig. one every two hours till hypnotic effects are secured.

In such cases as these the salt perhaps would be better made into a normal pill weighing ·2 gram. All pills can thus be readily reduced to the standard by proportionate variations in their ingredients.

In like manner it would be exceedingly easy in the decimal system to make all mixtures of solids in such proportions as would give the leading ingredients the average dose in the standard dose. The case of the compound cathartic pills will illustrate the whole series.

Thus these pills made according to the following recipe contain precisely the same proportion of compound extract of colocynth, calomel, jalap and gamboge, as the pill formed according to the formula given in the "U. S. Dispensatory," but each pill will of course be standard, *i. e.*, contain ·2 gram which is a very little less than the ordinary pill.

℞ Comp. ext. colocynth, grams xij.
Ext. jalap,
Calomel, āā. grams jx.
Gamboge, grams ij.

Mix, make 160 pills.

This would give pills of the standard weight, and one of these would be an ordinary dose for a mild laxative. Thus we see that by means of the metric system all prescriptions for solids may easily be made to conform to the standard dose; a thing which would be almost impossible under the present system of weights. Again, all substances which are given without mixture may be made *normal*, in fact can easily be made so. In case, however, the substance is of such a nature that the standard dose is not sufficient to produce the required effect, it should be so mixed that two, or three, or four, times the standard dose would be the average dose for the adult patient. It should then be labelled (½ N) (⅓ N) (¼ N) etc., signifying that the dose is twice, three times, four times, etc., etc., the standard.

On the other hand, should it be inconvenient to dilute the very active solids, such as morphia, to the normal, let the dilution be in

some multiple of the normal and labelled (2 N) (3 N) (4 N) etc., signifying in each case that the dose is one-half, one-third, one-fourth the standard.

But this is, I hope, sufficient to present at least the outlines of the proposed plan of unification as far as it applies to solids.

Let us now consider the same problem in liquid medicines. It would be well to refer here to the table of comparison between minims and cubic centimetres. From this it appears that the most convenient standard dose of a liquid is $4cm.^3$ equivalent to 64 minims nearly, or one fluid drachm, or a teaspoonful. Let us take this then as a standard dose. The bottles in which medicines are given out could be furnished with glass stoppers hollowed out with a cup-shaped cavity measured to hold $4cm.^3$ Teaspoons are so variable in size that they are not always to be depended on to measure a dose. Of course as in the case of solids the manufacturing chemist should be required by law to put up only standard solutions or some multiple of that standard.

Nothing would be more easy than this and it is but right that the profession should be protected from the cupidity of manufacturers which leads them often to dilute officinal preparations. The government should appoint an inspector who should see that every liquid medicine exposed for sale is normal, *i. e.*, that a dose of $4cm.^3$ contains the average dose of the active principle in the liquid for the adult patient. In the case of laudanum, for instance, it is well known that when the crude opium is high the tincture is weak so that the physician is safe in prescribing twice as many drops when opium is twenty dollars per pound as he does when it is ten. Let us suppose, however, that we have some laudanum of ordinary strength of which 16 minims contains 1 grain of opium.

How now are we to standardize this solution in order to apply the principle of unification? The standard dose which we have assumed is $4cm.^3$ or about 64 minims. Hence if we dilute the laudanum with 4 times its bulk of water or mint water the solution becomes normal and then we may write

℞ Tinc. opii 1 decilitre ($100cm.^3$) (N).

Sig. $4cm.^3$ (a teaspoonful) before bedtime or until soporific effects are produced.

Here $4cm.^3$ represents 1 grain of the crude opium or nearly so. Again, the common officinal aromatic dilute sulphuric acid, diluted

with six times its bulk of water or mint water becomes normal and we write

℞ Sulph. acid dil. aromat. decilitre j (N).

Sig. dose every three hours.

(N) signifies always that $4cm.^3$ is the dose for the adult patient. Should it be desirable to administer quinine with the above acid the prescription can be varied thus,

℞ Aromat. sulph. acid, decilitre j (N),
Quiniæ sulphatis, grams v,

Mix. Sig. dose every two hours until cinchonism is produced.

Since the five grains of quinine dissolved in the acid would not increase its bulk appreciably, this increase is practically neglected (1 decilitre is 3½ fluid ounces nearly). Again, the ordinary dilute phosphoric acid by the addition of one-half its bulk of water or mint water becomes normal and, as before, we write

℞ Phos. acid, dil. decilitre j (N).

Sig. every four hours.

Or if it be desirable to give strychnia in the phosphoric acid,

℞ Phos. acid, dil. decilitre j (N),
Strychnia, ·04 grm.,

Mix. Sig. every four hours.

We thus administer about $\frac{1}{30}$ gr. strychnine at each dose, etc. It is not worth while to multiply examples. I hope that I have made my idea clear; that at least this paper may direct the mind of the profession to the merits of the metric system which is certain sooner or later to reform the nomenclature of remedial quantities.

If it be urged in objection to the foregoing suggestions that there would be great difficulty in making and keeping these normal solutions, it will be sufficient in reply to call attention to the fact of their very general introduction into the science of quantitative chemical analysis within the last few years. The analyst has found his work greatly lessened and calculations simplified by their use. I can safely affirm that every practical analyst who has ever made use of these normal solutions will cheerfully bear witness to the beauty and simplicity of the modes of analysis into which they enter. With a burette, a pipette and litre flask it is possible to make analyses which would require by the gravimetric method extensive and costly apparatus. I can easily see how in like degree the physician and apothecary would be benefited by the of normal remedies, and the consequent unification of doses.

Another objection, which it is well to anticipate, will be urged against the normal remedies when it is desirable that several of them be exhibited together. As each one of the constituents of the mixture requires a dose of $4cm^3$, or ·2 gram, it may be said that four or five of them together would inflict upon the patient a dose of enormous proportions; but in the case of mixtures it does not follow at all that each ingredient of the compound must furnish its standard dose to the general dose. On the contrary, it is quite possible that a standard dose of the compound containing one-half, one-third, or one-fourth, etc., the standard of each ingredient, according to the whole number entering into the mixture, would be the proper amount to be given at once. To the thoughtful and competent practitioner it will not seem extravagant to say that a prescription containing half a dozen or more ingredients serves oftener to show the egotism and pedantry of the doctor and to bother the druggist than to benefit the patient.

When however it becomes necessary, as is often the case, that remedies be exhibited together, they may easily be prepared from the standard mixture and normal solutions, and the dose regulated accordingly.

If, for instance, it were desirable to administer balsam of tolu, laudanum and syrup of squills together, the prescription could be made as follows—

℞ Balsam Tolu (N),
Laudanum "
Syrup of Squills " āā $\frac{1}{3}$ decilitre.

Sig. every four hours.

The same reasoning will apply in the case of solids, so that the whole subject of mixtures becomes a simple problem of ratios, which can be altered at pleasure. In the above mixture the proportion of either ingredient could be changed, taking care only that the whole should amount to a decilitre.

But finally it may be said that the druggist should keep not only the normal drugs, but also keep them in their ordinary forms. The physician could then have his mixtures made by the apothecary as in the case of strychnine and morphine already given, only taking care that the medicines when finally ready should be of such a constitution as to be given in the standard dose. In the case of children or very weak patients where the standard dose is too large, it will only be necessary to write after

the (N) at the end of the prescription a fraction denoting what part of the standard dose is to be given. Thus, ℞ Laudanum (N)$\frac{1}{10}$ or $\frac{1}{10}$(N) would show that only one-tenth of the standard dose was to be given. In the case of solids $\frac{1}{2}$(N) would direct the druggist to put up in ·1 gram doses, etc. With the proposed changes unifying the doses of medicine it would be almost impossible for forgetful or careless nurses to disregard the directions of the physicians. By the present system where often three or four different remedies are administered from different bottles during a single day, it is not at all strange that the nurse should become confused and do everything wrong. Every one can see how the possibility of such mistakes would be removed by the Unification of Doses.

Cyclonism and Anticyclonism. By Pliny Earle Chase, of Philadelphia, Penn.

By cyclonism, I mean that the current of air at the point of observation is cyclonic, or curves towards the left; by anticyclonism, that it curves towards the right. By a cyclonic or anticyclonic storm, I mean a region of precipitation where cyclonism or anticyclonism, as here defined, exists.

Of course in a typical Espy-storm, modified by the earth's rotation, there is cyclonism toward the centre, and anticyclonism toward the circumference. But such a storm can never occur until there has been precipitation enough to produce a local, partial vacuum, and consequent indraught. It is desirable, in weather forecasts, to anticipate, if possible, the formation of the storm centres on the probable lines of prospective precipitation.

Such lines, which are more common than simple centres, may be straight, cyclonic, anticyclonic, or mixed, according as the originating pressure is direct, or modified by rotation in flowing toward a centre, from a centre, or in the areas of conflicting vortices; the vortices being either both cyclonic, both anticyclonic, or one cyclonic and the other anticyclonic.

The weather maps of the Signal Service Bureau show that a large proportion of the American rainfalls and snow-storms move so nearly in straight lines, that it is difficult to classify them as either cyclonic or anticyclonic.

One of the best illustrations I have seen of synchronous cyclonic and anticyclonic storms is afforded by the following observations, taken from the morning map for March 22, 1872:—

Stations.	Wind.	Weather.	Barometer.
Nashville.	E.	Snow.	30·32
Cairo.	S.E.	"	30·22
St. Louis.	"	"	30·11
Keokuk.	S.	"	30·05
Davenport.	"	"	30·14
Milwaukee.	S.W.	Cloud.	30·10
Escanaba.	0.	Snow.	30·09
Marquette.	S.E.	"	No report.
Duluth.	N.E.	"	29·76
Memphis.	E.	"	30·19
Shreveport.	N.W.	Rain.	30·04
Vicksburg.	E.	"	30·01

The storm was therefore anticyclonic at Nashville, Cairo, St. Louis, Keokuk, Davenport, with two cyclonic branches; one passing through Milwaukee, Escanaba, Marquette and Duluth, the other, through Memphis, Shreveport and Vicksburg. A slight new centre of pressure was formed by the meeting of vortices near Davenport.

The frequency of anticyclonism appears to be

Greatest in fair weather.	Least in storms.
" " winter.	" " summer.
" " snow-storms.	" " showers.
" near highlands.	" near water.
" in upper currents.	" in lower currents.
" " the country.	" " cities.
Greatest near anticyc. streams.	Least near cyclonic streams.

From a careful examination of thirty-eight thousand, five hundred and eighty-two observations, extending over a period of two years, from July 16, 1871, to July 15, 1873, both inclusive, I have deduced the following comparative tables of cyclonism (C), doubt (D) and anticyclonism (A), in each season of the year:—

	Fair.			Cloud.			Rain.			Snow.		
	C.	D.	A.	C.	D.	A.	C.	D.	A.	C.	D.	A.
Spring . . .	1194	2371	2298	1017	1415	851	273	234	98	124	144	51
Summer . .	1447	2679	2406	909	975	607	177	160	48			
Autumn . .	1042	2433	2009	956	1221	794	228	215	97	57	50	19
Winter . .	846	2393	1597	1185	1765	1108	155	173	74	257	277	153
Year . . .	4529	9876	8310	4067	5376	3360	833	782	317	438	471	223

The percentages of cyclonism and anticyclonism are given in the following table:—

	Fair.		Cloud.		Rain.		Snow.		Total.	
	C.	A.	C.	A.	C.	A.	C.	A.	C.	A.
Spring	34	66	54	46	74	26	71	29	44	56
Summer	38	62	60	40	79	21			45	55
Autumn	34	66	55	45	70	30	75	25	44	56
Winter	35	65	52	48	68	32	63	37	45	55
Year	35	65	55	45	72	28	66	34	45	55

The uniformity of the total ratios and their accordance with the general prevalence of anticyclonism, which was shown by Coffin's "Results of Meteorological Observations," seem to indicate the approximate accuracy of the detailed estimates. The amounts of cyclonism in fair weather, and of anticyclonism in cloudy and stormy weather, appear to be much greater than meteorologists have generally supposed.

A CHORD OF "SPHERAL MUSIC." By PLINY EARLE CHASE, of Philadelphia, Penn.

IN various communications to the American Philosophical Society, I have pointed out simple harmonic relations between planetary distances, which seem to indicate a tendency to cosmical aggregation at harmonic nodes, in a vibrating elastic medium.

In a paper, read on the second of May last, I introduced the harmonic series, $\frac{7}{2}$, $\frac{7}{10}$, $\frac{7}{18}$, $\frac{7}{26}$, $\frac{7}{34}$, of which the unit is the earth's mean radius vector. Finding representatives for the other terms, I stated that the term $\frac{7}{26}$ represents "a possible unknown planet, planetoid group, or other seat of solar and planetary perturbation." By Kepler's law the cyclical period of such a perturbation would be about 51 days. I also suggested that Wolf's sun-spot period of 27 days "might be readily explained by the perturbations and transits of a planetoid or meteoric group, at a distance which would complete the terrestrial harmonic series."

Professor Winlock kindly allowed me to examine the measurements of the sun's spotted area, at the observatory of Harvard University. They indicated such a periodicity as I was looking for, but as the observations covered a period of less than five months, I did not regard them as conclusive.

I subsequently found in "Nature," of July 17th, an abstract of a communication to the Royal Society on June 19th by Messrs. De La Rue, Stewart and Loewy, who find evidences of a tendency in sun-spots "to change alternately from the north, or positive, to the south, or negative, hemisphere and *vice versâ*," and "*that the two outbreaks are at opposite ends of the same solar diameter.*" Their inferences are drawn from observations taken in three different years and covering an aggregate period of 407 days. Their lowest approximate estimate of the mean interval between two maxima in the same solar hemisphere is 22·25 days; the highest, 28 days; "the most probable mean value, 25·2 days." The interval between two maxima of the same sign and originating at the same axial extremity would, of course, be twice as great.

Herschel (following Bianchi and Laugier), Spörer, Carrington and Faye, give estimates of the sun's sidereal rotations varying between 24·62 and 25·33 days. The evidence, therefore, seems conclusive, both of a cycle due to solar rotation, and of another,

due to some disturbing influence which revolves around the sun in a period approximately equivalent to two rotations.

The half-periods, being all made sidereal, and the corresponding mean distances, compare as follows:—

	Days.	Distance.
Spörer,	24·62	·263
Carrington,	24·97	·265
Faye,	25·07	·266
Wolf,	25·14	·267
De La Rue, Stewart and Loewy,	25·20	·267
Herschel, Bianchi and Laugier,	25·32	·268
Harmonic prediction,	25·51	·269

A STROKE OF LIGHTNING, WITH HINTS AS TO IMMUNITY. By JAMES HYATT, of Stanfordville, N. Y.

THE house of Mrs. Hallock, in Dutchess County, N. Y., was last summer "struck" by lightning, notwithstanding that each of some half dozen chimneys (all there were) had a branch rod attached, connecting with rods along the ridge and descending by three *separate* mains into the ground. Fortunately but little damage was done, some short bits of clapboard were cast off and a few splinters; but there was a vast amount of fright, and some of the inmates narrowly escaped with their lives.

Under the house is a well, connected by a large lead pipe with the pump in the kitchen. About five feet from this pump was the kitchen stove, with the usual iron funnel leading into a chimney, on which was one of the branching rods.

The son, then at home, an intelligent young man, was standing a foot or two only, aside from a direct line between the stove and the pump aforesaid, and a "farm hand" was near by. At the instant of the electric *coup*, this son was overthrown by the mere physical force of the discharge, though entirely untouched by the electricity. He describes the sensual impression as similar to that of the discharge of a piece of light ordnance, with the appearance before his eyes, as he expressed it, of a "large ball of fire."

The tin leaders, which descended perpendicularly, at several of the corners of the house, reached to within, perhaps, a foot of the ground. This ground, on which the house stands, is a dry, gravelly knoll of slight elevation, say about six or eight feet above the average level of the adjacent land. The three lightning rods descended into this dry gravel a few feet only, being practically insulated from the general body of water in the earth. At the lower termination of those perpendicular tin leaders, there was some slight splintering of the adjoining wood-work. At one place, where the course of the electricity was across a space of a foot or more between two of these leaders, some small nails were thrown out from the wood-work, in which they were embedded, as was shown by the hole which they left, which was also slightly splintered.

Having been consulted with by Mr. Hallock, the father, for some years now deceased, in reference to the protection of his house by lightning, I advised him, by all means, to connect his rods all well together, and to extend them, with sufficient size of metal, to the *bottom* of the well. This had been neglected; although Mr. H. had informed his family, before his death, apparently with some misgivings as to his failure to comply, that I had so advised him.

It was quite evident, that the main force of the electric discharge had, in this case, taken its course away from the lightning rods, across the kitchen, from the stove to the pump, and so on to the well, as I had anticipated.

In common with all students of the electric force, I consider that no safety is to be had from the effects of lightning, but in the perfect connection of the rods altogether, and the extension of the conductors, for many feet into the general mass of water which lies at or below the surface of the earth.

While I do not imagine that any such extensive metallic connection with the water is necessary, as one hundred square feet, which has been spoken of as required, still it is well to err, if at all, on the side of safety. With a protection, in addition, of every projecting portion of the house, by means of a branch rod, I have no doubt that a building may be about as safe from electric discharges, as it is from floods, when placed on an immovable foundation, above any possible rise of water.

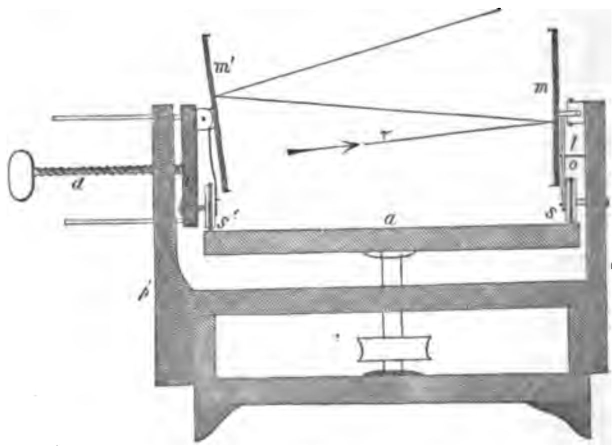
Subsequent to the occurrence, here narrated, I personally and carefully examined the premises. The case may be instructive.

An Attachment to the Whirling Table for projecting Lissajou's Curves. By A. E. Dolbear, of Bethany, W. Va.

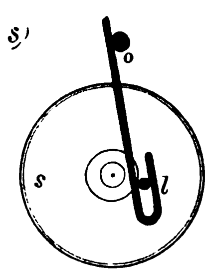
The costliness of the usual apparatus for the projection of Lissajou's Curves has led me to devise a method for accomplishing the same results in a comparatively inexpensive way, which proves in other ways to be superior to the method with vibrating forks.

It consists of the following attachment to the Whirling Table.

Two posts p and p' are made fast to the frame upon the opposite sides of the inertia plate a. A small wooden pulley s, about



an inch in diameter is made to turn upon an axis that is made fast in the post p, and with such adjustment that the pulley rests upon the plate a and turns by friction on that plate. It is best to have a thin india rubber ring upon the friction pulley to insure it from slipping. Above the pulley the mirror m is so mounted as to swing in azimuth and is made to do this by a wire fastened to it at its hinge and bent into a loop l at its lower end, which is opposite the face of the pulley s. Another twist in the wire at o will be needed, for a pin which is fast in the post p; this will make a lever of the wire l, with the fulcrum at o, and if it is properly fastened to the hinge of the mirror will cause it to vibrate in a horizontal plane when the plate a revolves.



A somewhat similar arrangement is made for the other side, save that the friction pulley s' has its bearing made fast in a separate piece c, which is so fastened to the end of a long screw d that the whole fixture can be moved to or from the centre of the plate a. The piece c is furnished with two guides which keep it steady in any place where it is put. The mirror m' is made to tilt in a perpendicular plane by an arrangement quite similar to the former one, save that the wire connection has its lower end bent into a horizontal loop through which a pin in the face of the pulley s' is thrust. This is practically an excentric and, being directly fastened to the hinge of the mirror m', gives to it an angular motion proportional to the distance of the pulley face pin from the centre. The mirrors should be not less than two inches square. If then the pin is an eighth of an inch from the centre of the friction pulleys, they will have ample angular motion; much larger than can ever be got from forks.

Experiments.

It is evident that if the two friction pulleys have equal diameters and they are at equal distances from the centre of the plate a, they will vibrate in unison in their respective planes. Now let a beam of light r, from the *porte lumière*, fall upon the mirror m at such an angle as to be reflected first upon the mirror m', thence to the screen. If the plate a is now revolved the beam of light will describe a circle, an ellipse or a straight line, either of which can be made at will by simply adjusting the crank of one of the mirrors to the required angle. Thus, suppose the mirror m' is tipped back its farthest by bringing the pulley pin at the top, as indicated in the drawing, at the same time that the mirror m is at its maximum angular deviation. The beam of light will describe a circle.

If it moves slowly the path and direction of the moving beam can be nicely observed. These two advantages are not to be had with forks; for, first, it is accidental if one gets a circle or any other desired resultant figures from forks in unison, for the obvious reason that the phases cannot be regulated, and second, the vibrations of the forks are so rapid that the analysis of the motion can only be made in a mechanico-mathematical way.

By moving the fixtures on the left side toward the centre of the plate a, the pulley s' will not revolve so fast. If moved half-way it will make one revolution while the other makes two, and the vibrations stand in the ratio 1:2 represented by forks in octave.

Such ratio is shown upon the screen by a form very much like the figure 8, and known as the lemniscate.

Between these two places, every musical ratio in the octave can be got and the resultant motions projected in their proper curves. More than that, *while the mirrors are both vibrating*, any of the ratios desired can be moved to at once by merely turning the thumb screw *d*, which is wholly impossible with any forks which require stoppage and adjustment of lugs for each different curve.

Again, if the fixture *c* is moved still farther toward the centre than half-way, the curves projected will be those belonging to the second octave, until the pulley reaches three-fourths of the way, when the ratio will be 1 : 4 and the resultant figure will be like a much flattened double eight.

If one would show the phenomenon of beats it will be necessary to have the mirror *m* and its attachment so adjusted as to have it vibrate in a perpendicular plane like *m′*. This can be done by fixing its hinge at right angles and the rest the same as for mirror *m′*. The reflected beam from the second mirror may be received upon a large mirror held in the hands and thence reflected upon the wall or screen. All the phenomena of vibrations that can be shown by forks can be reproduced on a scale that is not approached by means of them, by any one possessing a turning table, and at less than the fifth of their cost.

On the Convertibility of Sound into Electricity. By A. E. Dolbear, of Bethany, W. Va.

I have found by experiment that if a vibrating tuning fork have its stem applied to the face of a thermo-electric pile, which is in circuit with a delicate galvanometer, the needle will be deflected, showing that electricity has been developed in the pile. The question is as to its immediate origin. It may be asserted that the vibrations of the fork are competent to develop heat, which, in its turn, is converted into electricity, so that its appearance is a secondary phenomenon. To this explanation countenance is given by the experiment of Professor Henry, who found

that the deadening effect of a rubber cushion, when the stem of a vibrating fork was put upon it, was due to the fact that the vibrations were converted into heat. But the vibrations are not noticeably deadened in the former case, and the junction of the metals is subject to definite and measurable vibrations.

The antecedent to the production of electricity is the contact, either mediate or immediate, of substances, which differ in composition or in condition, and if electricity is a mode of motion it ought to appear whenever a motion may be set up at such point of contact as mutually to disturb the molecules of the differently constituted matter. That the vibrations of the fork are competent to do this without necessarily giving rise to the phenomenon of heat may fairly be inferred, I think; so that, *a priori*, one should look for electric phenomena from such a combination of favorable conditions. At any rate it will hardly be asserted by any one, that *because* the electricity is generated in the thermo-pile its immediate cause *must be* heat. I do not know that it has ever been proved that heat motion was the only kind of motion that was capable of direct conversion into electricity in the so-called thermo-pair. It is probable that the more general statement is true, namely, that molecular disturbance at the junction of dissimilar metals will give rise to electricity.

We know that the molecular disturbance called heat will give rise to it, and it is not improbable that the disturbance, caused by a regularly vibrating tuning fork, may do the same thing directly. My experiment does not prove that such is the case, but it hints at it, and I offer these considerations to meet the objections of some who take it for granted that it cannot be true that sound vibrations are really converted into electricity, except in an indirect way. This is capable of verification I do not doubt, but I have not had time to apply the *experimentum crucis*, as the idea did not occur to me until a day or two ago, and I bring it to the Association as an interesting experiment, whatever its *rationale* may be.

THE "TORNADOES" OF ILLINOIS. By M. L. COMSTOCK, of Galesburg, Ill.

THE "tornadoes" which occur in different parts of the United States are so remarkable in their sudden rise, and in their destructive effects, as well to deserve the most careful observation and study; not, perhaps, with any well founded hope of averting them, but that their occurrence may be foreseen a few hours, and places of safety secured by persons in danger.

Very severe, if not the most remarkable of their class, are the "tornadoes" that visit Illinois. I do not propose to theorize very much in this paper, but I shall, in a simple manner, state such facts as have fallen under my own observation. My notes will refer to two storms which occurred May 3, 1868, and May 22, 1873.

The first of these visited a village called Shanghai situated 14 miles northwest of Galesburg. The length of the track in which serious damage was done fell short of five miles, with a width of half a mile. Shanghai occupied the middle of this line, and the centre of the storm passed within the limits of the village. A few days after the storm, I visited the locality, and examined carefully a tract of land one and a half miles long and half a mile in width. I found everything levelled to the ground—churches, dwellings, fences, trees—though as the place was upon a prairie there were no forest trees, except a few transplanted ones of diminutive size. The course of the storm through the village was N. 70° E.; before reaching it, N. 80° E.; after leaving it, N. 60° E.

South of the central track, buildings were moved north; some of them N. 20° W., or even N. 25° W., appearing in many cases to have been carried perpendicularly to the central line of the storm. Trees near this line had been thrown toward the northeast and fences had been carried in the same direction. A new board fence with green white oak posts stood directly across the line of the tornado. This was left standing, except a few rods near the central line. Straw and dirt were blown only against the west side of this fence and the rubbish was packed into the angle between the post and boards as if driven violently from the southwest. North of the central line, buildings were moved south and east of south. The trees of an orchard were thrown down to the south almost exactly; and upon carefully examining the fence before mentioned the rubbish was found to be packed in the angles from the northwest.

There was no evidence of a whirl anywhere. It seemed as if there had been a travelling point, toward which the air rushed with great velocity from various directions, but especially from the sides. Objects were thus swept toward the central track, then upward by ascending currents, then forward by the moving body of the storm. The disturbance did not extend far from the centre, and the rate at which it was propagated did not differ much from the progressive motion of the storm; hence the disturbance in front of the storm was slight until it burst with its full force. South of the central track I found nothing blown south of the point from which it started, and north of the same line nothing north of its starting point.

Such results would hardly have been possible if there had been a whirlwind, especially if the whirl had occupied several rods in width; for the front of the storm would carry objects in one direction, and the rear in exactly the opposite direction. Trees partly uprooted would be twisted around and thrown out by the roots, and in some cases certainly must have left signs of these different movements. I made this the special object of my search, for persons who were in the "tornado" had affirmed that there was a whirlwind, but I could not find the least evidence of any such action. Again, if the whirl had occupied only a point, or a very small space upon the surface of the earth, objects along the line of its travel would, no doubt, have been twisted, but there was no appearance of the kind. True, I found evidence of a change in the direction of the wind in some places, and more evidently near the central track. One church was moved from its foundation N. 10° W., but the ruins were carried N. 45° E. This church was south of and near the central track. Twenty-five rods farther south another church was blown down, the sills moving seven feet north, and two feet east, while the *débris* was carried northeast. At equal distances north and south of the central track, the lines of direction of the wind made equal angles with that track, and changed so as to become more nearly parallel with it as the storm advanced.

As to general facts; the morning of the day had been showery, becoming very warm. The latter part of the day was sultry, the atmosphere being near the dew-point. The clouds formed and moved rapidly. The thunder and lightning were not remarkable for this country.

The storm of May 22, 1873, passed through Warren and Fulton counties, twenty miles south of Galesburg. There had been a heavy rain in the morning in this part of the country; the day was sultry; the atmosphere near the dew-point. But the movement of the storm was not as rapid as that of 1868, and it was much more extensive in its sweep. The exhibition of electricity was not remarkable. After striking the surface of the earth, in going east six miles it went south half a mile; then east four miles, south three-fourths of a mile; then east four miles, south one-fourth; then east three, south one; then east one, south one; it then appeared to rise, passing over a body of woods and the valley of Spoon River, striking the earth again and pursuing the same general direction. The cloud accompanying this storm was quite extensive (another "tornado" having burst from it near Washington, Iowa, seventy-five miles northwest), but its destructive effects were apparent upon a strip not more than half a mile wide. Every house near the central track was destroyed or nearly so. One frame house was unroofed, and everything movable carried out of the upper story; the second floor was sprung upward and curtains from below drawn through the openings made between the ceiling and side walls. Here there seemed to be a strong upward current, though the effects named may have been produced by a horizontal current across the open top of the house. Apple trees a foot in diameter were carried from an adjoining orchard three-fourths of a mile. The roof of the house, the barn and other buildings were carried north toward the central track, which was about ten rods distant. So on the north side of the track, buildings and trees were thrown in a southerly direction. Thus the general lines of direction were toward the central track; and on the central track, as nearly as I could determine, objects were carried in the direction in which the storm travelled. One neighborhood exhibited singular results. On the north side of the central track, just where the storm began to move one mile south in three miles east, a dwelling standing on high ground was demolished, the timbers, furniture, etc., being literally broken to pieces and carried N. 80° W., while the large trees of an orchard standing northwest of the house, and prostrated after it, as shown by the relative position of scattered objects, were uniformly thrown S. 80° W. Other buildings not far distant, but all on the north side of the central track, were thrown toward the west. This is

the only place at which I could find the least evidence of a whirlwind; and it may be that this was but the first meeting of the storm with a body of cold air flowing from the woods of Spoon River, which finally diverted the tornado from its direct course and caused it to rise from the surface of the earth. South of the central track and opposite this last mentioned dwelling the currents of wind seemed to bear the same general relation to the central track as was observed commonly.

I present these, then, as two specimens of Illinois storms, hoping that the facts may add somewhat to the data by the aid of which some philosopher will yet explain all the secret workings of these wonderful phenomena.

New Theory of Geyser-action as illustrated by an Artificial Geyser. By Edmund Andrews, of Chicago, Ill.

Bunsen suggested the following theory of the action of geysers which, in default of any better, has been generally adopted, viz :—

The volcanic rocks of regions where geysers exist must necessarily contain caverns and passages capacious enough to hold and transmit the fluids which they eject at intervals from their orifices. Now the deep vertical well, from which the jet issues, must be subjected to constant heat from the surrounding rocks. The water in this pit will boil at a higher temperature in its lower, than in its upper portions, because of the greater pressure in the deep parts. Now, when the whole column has by the heat of the rocks been brought nearly to the boiling point, if a jet or belch of steam from some superheated cavern rush into the lower part of the pit, and lift the whole column of water a few feet, the upper portion will flow off and the whole column be made shorter by the exact amount of the uplift. All portions of the column being nearly at the boiling point before, they will, on this relief from pressure, break into sudden ebullition. The uprush of so large a volume of steam, intimately mingled with the water, would carry up a mass of foam and spray, which might for a few moments mount high into the air, thus causing an eruption.

Prof. Tyndall illustrated Bunsen's idea by the use of a vertical iron tube six feet in length and supplied with water. A fire, applied around the central portion of this tube, caused it to eject its mingled steam and water at regular intervals.

This explanation is interesting, and probably the force referred to in it acts to some extent in modifying geyser-phenomena, but, from the description given by eye-witnesses of the eruption of the great geysers of the Yellowstone River, the main principle must be something different.

On Bunsen's theory the eruption ought not to consist of clear water, but of an intimate mixture of steam and water; in other words, of foam and spray. But Maj. Barlow of the Corps of Engineers of the U. S. Army, who was sent to examine the geysers of the Yellowstone, asserts that they throw a great stream of

Fig. 1. Natural Geyser; S, Supply channel; H, H, Region of heated rocks; C, Cavern; O, Outlet; G, Geyser; P, Point to which the water in the supply channel is forced down during eruption.

clear water, which, in some springs, maintains itself steadily without mixture of foam for nearly half an hour at each eruption, while the steam escapes at the close as if released from a cavity. Furthermore, on Bunsen's theory the eruption ought to be very brief, for the steam formed by the ebullition in the pit would escape in a very few moments, and the heat consumed by its formation would as speedily reduce the remaining water to a temperature where the boiling would cease.

It would seem that the following explanation would much better account for the phenomena as observed by Maj. Barlow, and I find that an artificial apparatus reproduces them with great fidelity.

As the cooler waters of the surrounding country make their way into and through the caverns of the region of heated rocks, it will sometimes happen that the channel of supply will enter a cavern at a point higher than that where the channel of exit leaves it. If now this channel of supply has, like many other subterraneous watercourses, some portion of its course much lower than the point of its entry into the cavern, we have all the main conditions necessary for a geyser. Let Fig. 1, p. 116, represent these conditions.

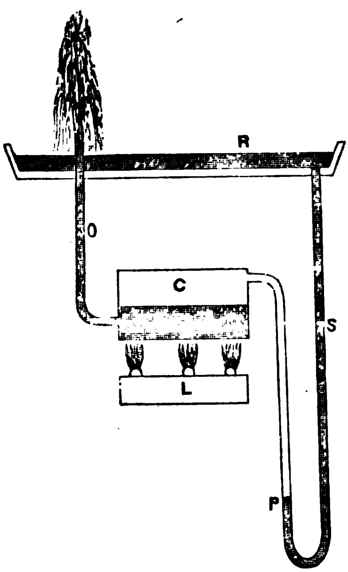


Fig. 2. Artificial Geyser seen in Section. R, Reservoir; S, Supply pipe; C, Boiler representing cavern; L, Spirit lamp or other supply of heat; O, Discharge pipe.

Suppose now that the whole of the caverns and passages are full of water. The heat of the rocks H, H, in which the cavern is situated, aided perhaps by superheated water and steam forced up through crevices from deeper volcanic sources, will soon cause the water in the cavern C to boil. The pressure of the steam accumulating in the top of the cavity will resist the further influx of cool water from the supply channel S and perhaps force it back

down the channel to a point P where the hydrostatic pressure of the column S resists further progress of the stream in that direction. Meantime the steam accumulates more and more in the top of the cavern and by its rapidly increasing pressure forces out the water through the channel of exit O, producing the jet G in the external air. As long as the level of the water in the cavern is above the orifice of exit, the jet will consist only of clear water, but when the cavern is emptied down to the level of the outlet pipe, the steam escapes with violence and relieves the cavern of its pressure. The cool water of the supply channel, no longer meeting any resistance, rushes in, cools the chamber and fills it, after which another eruption will occur as soon as the water is heated to the boiling point.

I have constructed several artificial geysers on this principle and find that they are perfectly automatic and produce their eruptions with great regularity. Fig. 2 illustrates the plan of their construction.

These artificial geysers are very satisfactory in the fact that they throw a stream of clear water, which, like that of the natural ones, is sustained for a considerable period and is followed by a gush of steam at the close. It would seem probable therefore that they illustrate the mechanism of the great geysers of the Yellowstone Park better than the form suggested by Bunsen.

THE ARCTIC REGIONS:—THE ARCTIC BASIN; THE ARCTIC OCEAN; ITS OUTLETS AND INLETS; ITS CURRENTS AND THE GULF STREAM; FOG AND ICE-BLINK; CLIMATE OF THE ARCTIC REGIONS, THE STORY OF SPINKS AND OTHER EVIDENCE, CONSIDERED WITH REFERENCE TO THE ATMOSPHERIC THEORY OF AN OPEN SEA AND AN AMELIORATED CLIMATE. By WILLIAM W. WHEILDON, of Concord, Mass.

No portion of the globe is of so much present interest to physical geography, and to science generally, as the Arctic Regions; and it is remarkable how continually, from a very early period in

the history of navigation and discovery, attention has been directed to, and an interest maintained in, these remote regions; the most uncongenial in themselves, the most repelling to human pursuit and yet so attractive that men of rank and position have been unable to resist the desire of making themselves more "notable" by some fortunate discovery or success in them. In no other part of the earth has so much hazardous enterprise, indomitable perseverance and enduring labor been brought out, prompted and inspired as these have been by the prospects of trade, the pursuits of science and the promptings of humanity. This is so true that at the present time, when science is ardent and earnest in its desire of arriving at knowledge and truth in regard to these regions, there is in the community a seeming unwillingness to encourage further exploration and exposure of life in those cold and icy desolations. Every proposition for further effort seems to send a chill through the sensitive blood of the civilized world and the question is often asked of what use is a further exposure and waste of human life in this perilous pursuit.*

Yet the demands of science on one hand, and that longing curiosity among the unscientific, who have of late years read and heard so much to excite their attention concerning these occult regions, on the other, seem to justify each new effort to reach the impenetralia of the Arctic circle. So much has been said in this behalf by scientific men and others that, in this place at least, no word need to be added and no justification of past or present efforts is required. It is no new thing for scientific men to assume great risks when there is an object to be gained, nor yet to permit apprehension or fear to defeat a high purpose. All that we know

*The actual loss of life in the Arctic regions, among explorers, is known to have been relatively very small, the deaths less than in the same number of persons at home. Mr. Simmonds says, "Out of ten searching vessels in three years, including Americans, but one man died, nor did any casualty occur to the ships or their sledging parties; indeed not more than twenty deaths in the present century out of fifteen hundred men employed and not half of the twenty attributed to climate or perils encountered." In a perilous voyage of four years, the Investigator lost one officer and five men out of a crew of sixty-five. There were one hundred and thirty-eight officers and men lost in the Franklin expedition—a much smaller number of lives than have been lost in some of the disasters on the Atlantic ocean.

Since the above lines were written, in view of the recent Polaris expedition and its results, a new interest has been excited in the public mind; a feeling of competition seems to have arisen between the United States and England as to which of the two peoples shall accomplish the desired object of reaching the central portions of the Arctic ocean. In both countries new expeditions are suggested and urged upon the respective governments.

is the reward of labor and more or less of danger. In medicine and surgery, in chemistry and engineering, ardent men have put their lives in hazard for science or for humanity, and in mining and the ordinary navigation of the sea, risks are assumed mainly for pecuniary benefits which it sometimes seems not easy to justify.

In the various and continued attempts to explore the interior of Africa we see the indomitable spirit and enterprise of man, prompted by a worthy ambition to become a discoverer in geography, history or science, sometimes rewarded by a drear and lonely grave, hardly less fearful than that which terminated the efforts of Sir John Franklin and his brave companions. There is nothing that can be suggested in the way of adventure or exploration, which promises a pecuniary reward, that will not find individuals ready to undertake it; and there are those devoted to scientific pursuits, as ardently disposed, as daring and it may be as uncompromising in their undertakings.

The early attempts to reach the Arctic regions were made in the very infancy of navigation, and have been continued to the present time almost without interruption by the different maritime nations, keeping pace with the progress of naval architecture, navigation and science; and it is almost true to say, success has been in proportion to the means employed.

ARCTIC BASIN:—The late Prof. Henry D. Rogers, in his Physical Atlas published in Edinburgh, includes in the Arctic basin ("equivalent to the Arctic Regions") all those wide circumjacent lands which empty their drainage into the great polar sea, and describes the region as follows:

"The Siberian division of this enormous region of converging and rotating waters includes the great rivers Obi, Yenessi and Lena, and extends southward to latitude 50°, taking in all northern Asia from the Urals to the sea of Okhotsk, while the North American portion embraces the vast basins of the Mackenzie, Saskatchewan and Hudson's Bay, and reaches quite as far southward. Viewing Greenland and the countries bordering Behring Strait as portions of the Arctic regions, it will be seen to include all the lands, excepting northern Europe, which lie between the pole and the circle of 50° north latitude. The broad zone of land thus bounded and draining into the polar sea has an area of about five million square miles. The river systems of the Obi, Yenessi

Lena and Kolyma, in Asia, with those of the Mackenzie and Saskatchewan, in America, alone cover a surface of more than 3,200,000 square miles or equal to that of all Europe."

Another writer speaks of the Arctic basin as including six millions of square miles, surrounded by an ice barrier and receiving the waters of more than 3,500,000 square miles of land. The polar sea, Prof. Rogers says, has an approximately circular line coinciding roughly with the parallel of 73° north latitude. This would give to the sea a diameter of more than two thousand miles: four hundred miles wider than the Atlantic ocean between Newfoundland and the coast of Ireland. Capt. Barrow considers the polar sea as a circle, on the latitude of 70°, of two thousand four hundred geographical miles in diameter and seven thousand two hundred miles in circumference; and regards the talk, at one time common, about its being exhausted by southerly currents, as absolute nonsense: since that time some theorists have poured both oceans into the Arctic ocean, without much reason for either.

THE ARCTIC OCEAN.—The great mystery of the Arctic regions is still in the Arctic ocean, the interior of which is yet to be reached; and so long as it remains unknown it will be the subject of speculation and assertion, based it may be to some extent upon what we know of its approaches and its borders. It is taken for granted that it must be peculiar and different from the other oceans, and the opinion has heretofore prevailed that it is completely frozen over for the whole or at least a portion of the year,—which can hardly be the case if subject to a tidal wave, even if the winds and storms do not keep it from freezing—to say nothing of an ameliorated climate or other external influences. But aside from these it seems improbable, as we have heretofore shown, that so large a body of water can be frozen over. Lake Superior (fresh water) is never wholly frozen over, nor is the well-known "north water" of the whalers, in Baffin's Bay;* and it is said by a distinguished astronomer, that "were the ocean covered by a substance of moderate thickness, say of ice, the reaction of the water, caused by pressure from being drawn up into a temporary heap by the attraction of the moon passing over it, would

* HAYES.—"The little sea at the head of Baffin's Bay, the north water of the whalers, although but eighty thousand square miles in superficial area, is never entirely frozen over, even during the severest weather."

be so powerful as to break it up into innumerable pieces."* Whatever else may be said of the Arctic ocean, it will hardly do hereafter, to speak of it otherwise than as an open sea.

This vast ocean is spoken of in the quotation which we have given, as "an enormous region of converging and rotating waters," terms which are not applied to any other ocean and intended, no doubt, by the writer to be descriptive of this according to his information on the subject. The region of the polar sea within which is included the theoretic axis of the earth, owing to the flattening of the surface and the slower diurnal motion, is peculiar in these respects, and is subject of course to the severity of the climate by reason of the absence of the sun. So far as the waters of the great rivers which have been mentioned, or waters from either of the great oceans, flow into it, they may be said to be "converging;" but that its waters are "rotating" in a peculiar manner, so as absolutely to form a rotating ocean in itself, irrespective of and independent of the rotation of the earth, seems to be an assumption not authorized by anything that we know, and in fact essentially opposed to all accepted information on the subject. It seems to be supposed that because this ocean surrounds, so to speak, or includes the position of the theoretic pole, it must therefore revolve around that *object*, as it has come to be regarded: an American writer recently suggested that Capt. Hall would be able "to set his foot upon the pole itself," and Capt. Barrow once said that on "his plan a month would enable the explorer to put his foot on the point or pivot of the axis on which the globe of the earth turns." [Simmonds, p. 105.] Nevertheless it is to be presumed that the Arctic ocean has its tides and currents, both of which have been observed, as other oceans have, and possibly resembles them in other respects.

Its Outlets and Inlets:—"This sea," continues Prof. Rogers, "has really but two outlets into the general ocean of the globe, one of which, Behring Strait, is less than thirty miles wide, and, what is of more consequence, is very shallow, having less than twenty-five fathoms of water in its deepest channel. As an *opening*, therefore, it is almost null; so that the polar sea, on this side, is virtually land-locked. The other much wider, deeper outlet is

*Rolp h Falb, editor of "Sirius," published at Gratz in Styria.

partially blocked by an immense belt of cliff-lined islands, from Iceland to the Parry Group, the largest being Greenland."

The Professor, proceeding with the subject of "Configuration," adds:—

"The sole practicable inlet to the polar sea is the wide channel between Spitzbergen or Iceland and the northwest coast of Europe. This is the broad highway for the northeast branch of the Gulf Stream."

Behring Strait Prof. Rogers first includes as one of the "really but two outlets," then rejects it as an "opening almost null," and finally in the same paper speaks of it as the inlet of "a sort of second gulf stream * * * prolonged from the Japanese current," and assisting in the rotating process already considered.*

"Thus enforced," Prof. Rogers continues, "it [the Gulf Stream] washes the Arctic coast of America, where it preserves a lane of open water between the ice-pack and the shore, the greater part of the way from this inlet [Behring Strait] to the Parry Islands; there it streams through the great channels of this archipelago and clogs them with its vast drift of ice, until it finally works its way out into the Atlantic through Baffin's Bay and northward round Greenland, chilling as it flows southwestward all the northern part of America with ice-cold and ice-laden waters."

We do not know that the whole or any part of this statement, excepting for the favor it may receive from the public, demands any consideration beyond what we have given it upon the general subject of the Gulf Stream. By it an enormous work is put upon the assumed northeast prolongation of that stream, pouring its heated waters around Nova Zembla, sweeping around the Arctic ocean, "softening the boreal climates of Norway and Siberia," and with the aid of the Japanese current making its way into Baffin's Bay, etc., all of which needs confirmation. To say the very least of it that can be said, there is no satisfactory evidence of the prolongation of the Gulf Stream around Nova Zembla; none of its ameliorating the climates of Norway or Siberia; none that it is enforced by the Behring Strait current; and in fact no evidence whatever that any portion of its waters, in this direc-

*Prof. Davidson, of the U. S. Coast Survey, does not think much of the Japanese current for clearing a way to the pole, Behring Strait being only twenty-five miles wide, with an average depth of only twenty-five fathoms, and the rate of the current flowing through it being from a half to three knots per hour. [Amer. Ed. Monthly, February, 1873.]

tion or any other, reaches the Arctic ocean. And if this last, which has been so frequently asserted and still repeated, could be shown, there are no reasonable grounds of belief that its waters would retain force enough and heat enough for the purposes required. As to the velocity of the current or drift there is but little evidence of any kind: what there is gives it a trifle over three miles per hour, at a point more than fifteen hundred miles from the pole. As to the heat of the water, Lieut. Maury's statement is that "a cubic foot of water which leaves the Straits of Florida at a temperature of 85°, on arriving at the frozen regions through the Gulf Stream, does no longer measure a cubic foot. It will have *wasted away* [?] by the way of contraction caused by a change in the temperature of some fifty or sixty degrees." So that the Gulf Stream water reduced to 25° (below the freezing point of salt water) would hardly answer Capt. Bent's purposes of assaulting the ice-girdle if it could reach it, whatever it might do for the other parties.

Besides all this the parties who advocate the Gulf Stream theory do not agree upon any plan; one or two of them pour the heated waters around Nova Zembla, without showing how they reach the enclosed polar sea; one or two of them sink the warm waters in the Spitzbergen sea and pass the current under the ice-barrier, and another party, represented by Capt. Bent, uses the heated waters to assault the ice-belt and open a gateway for themselves.* It is in vain, we presume, to expect these authorities to agree upon any theory as to the prolongation of the Gulf Stream; nor do any of them show that there is any necessity for the waters of the Gulf Stream in the Arctic ocean or for such a use of them. So far as yet appears, the Spitzbergen sea, from Nova Zembla to Greenland, *is an outlet* of the Arctic ocean and *not an inlet* as Prof. Rogers states. Failing in this particular, the whole theory, so fully set forth by him, fails also; and it remains only to be said, respecting

*Since this writing one of the leading newspapers of this country which has always favored the Gulf Stream theory, in one of its forms, published the following paragraph in its editorial columns:

"So far no researches have explained *the absence of the Gulf Stream influence* in the scene of Mr. Leigh Smith's recent voyage [in the neighborhood of Spitzbergen], *and it is hard to explain it.* The body of warm water drifted [?] into the polar basin by this Atlantic current must be many times as large as the Behring Strait current. What becomes of the former? Is it lost in the mid Arctic ocean, or is it diverted, as Dr. Petermann and others contend, over toward the Siberian seas?" [N. Y. Herald editorial, Oct. 20, 1873]. The error is in the postulate which is assumed.

outlets and inlets of the Arctic ocean, that all of them are measurably if not entirely outlets; and are absolutely required as such by the conditions of the ocean, its rivers, its rainfall and its vast water-sheds.

ITS CURRENTS:—It will be observed that upon the statement of Prof. Rogers the general movement of the waters of the Arctic ocean is to the eastward. It seems to us that the whole amount of evidence is against this statement. Dr. Kane has very truly said that "currents in the ice-flows is a complicated problem." One writer and advocate of the Gulf Stream under-current theory, in speaking of Scoresby's discovery of warm water below the surface, says, "*Be this as it may, the current of the Siberian coast is westward and a continuation of this flow is formed in the great polar drift of the Greenland and Spitzbergen seas.*"

The polar current, always running westerly and southerly, is well known to all navigators of the north Atlantic and Spitzbergen seas, if not to those of Baffin's Bay, and is variously described as follows:—

"The polar current coming down through the Spitzbergen sea, along the eastern coast of Greenland, laden with its heavy freight of ice, and bringing from the rivers of Siberia a meagre supply of drift wood to the Greenlanders, sweeps around Cape Farewell and flows northward as far as Cape York, where it is deflected to the westward," and joins the current from Smith's Strait. [A little assumption, in this case, similar to that of Prof. Rogers, would authorize a statement directly opposite to his, viz: that the Arctic ocean is a "converging and rotating sea," flowing to the *westward*, from Behring Strait along the coast of Siberia, across the Spitzbergen sea, and around the southern, or it may be northern coast of Greenland. There is, we believe, as much authority for this statement as there is for that of which we have spoken.]

Another writer says, "The north polar current, after passing around the north cape of Europe, crosses the upper part of the Atlantic, running to the southwest till it reaches the coast of Greenland." Capt. Buchan, in 1818, off the north coast of Spitzbergen, was drifted to the westward. In the following month, July, while secured to a field of "ice, we had the mortification of finding ourselves drifting fast to the southward." [Beechey, pages 83 to 109.] Another explorer suggests that as the current through Behring

Strait runs to the north, and that between Spitzbergen and Greenland to the south, it may be that the former current extends across the pole; and this suggestion is at least partially sustained by Capt. Parry's experience. In speaking of the current which drifted Capt. Parry down towards Spitzbergen from latitude 82° 45′, Capt. Beechey says, "What may be the cause of this current can, at the best, be but conjecture; and we must at present remain satisfied with the knowledge of the simple fact." This drift was only about four miles a day, while Capt. Ross (according to Lt. Maury) reports the current through Behring Strait at from seventy to one hundred miles per day.

There can be no doubt, we apprehend, about the direction of this well known polar current, from the Siberian coast or Nova Zembla, across the Spitzbergen sea towards Spitzbergen and Greenland, which, it will be seen, must absolutely *cross the assumed prolongation of the Gulf Stream!* The latest intelligence from this region is that furnished by Dr. Petermann of Gotha, who has given special attention to the Spitzbergen sea and regards this as the proper region of approach to the pole. In one of his recent circulars, he reports the progress of the Norwegian and Austrian expeditions, (October, 1872), and says:—

"Capt. Nils Johnson sailed on May 8, in the sailing yacht Lydiona, of twenty-six tons burden, with a crew of ninety men, from Fromscoe, Norway. He directed his course in June towards the western half of the open sea, and, in the second half of this month (June), when the Austrian exploring steamship Tegethoff had just left the German coast, was already some fifty miles east-southeast of the island of east Spitzbergen, in the middle of the usual position of the polar stream, which generally carries an enormous mass of ice towards Spitzbergen and the Bear Islands. In July and August of this summer [1872] the ice current held a more easterly course, toward Nova Zembla, and left the western half of the sea free from ice, as the reports already received from Capt. Altmann [of Hammerfest] at the end of August had announced."

Capt. Johnson visited those almost unknown islands lying *east of Spitzbergen*, in latitude 76° to 78°, supposed to be what has heretofore been known as Wiche Land, and the most important discovery which he made there was the immense quantities of drift wood, sometimes piled twenty feet above the highest tidal mark along the eastern coast, from the Siberian rivers, brought down by

the polar current from the northeast, of course directly across the Spitzbergen sea.

In view of what has been said, it may be considered as certain that the waters of the Arctic ocean do not rotate around the pole eastwardly, as Prof. Rogers asserts, and that the direction of the polar current is westward and southwestward. The currents of Smith's Strait, Lancaster Sound and Baffin's Bay are all outward into the Atlantic ocean, and it only remains to speak of the current through Behring Strait. The reports regarding the movement of the waters in these straits are various and contradictory. Most of the navigators and writers declare that the current runs through the straits into the Arctic ocean, and others assert that the water runs out of that sea into the Pacific ocean. We have been told that it runs in on one shore and out on the other, but Kotzebue, who thought "as a constant current descends into Hudson's Bay on the eastern side of the continent, an equal flow of water must enter Behring Strait from the Pacific on the western side," says "the current from the south was equally strong on both sides of the channel."

The statement of Capt. Kerhallet* is quite different from the foregoing, and is as follows:—

"The current of the coast of Kamtschatka is a branch of the Japan current running toward the northeast and the north-northeast along the coast of Asia *as far as* Behring Strait.

"It separates from the Japan current on the meridian of 152° east longitude and on the parallel of 38° north latitude. Its eastern limit passes to the west of the Aleutian Islands, of St. Matthew's Island, and of St. Lawrence Island. There it passes through Behring Strait and spreads over the northern ocean, running northwest on the coast of Asia, northeast on the coast of America, and north in the middle of the strait.

"Behring's current appears to be formed by the excess of waters carried to the strait of this name by the current of Kamtschatka, which do not find a sufficient discharge through this strait. It perhaps owes its origin to some entirely different cause; but we have not observations enough to show whether this current is cold or warm.

"Behring's current descends from the strait of this name gen-

*"General Exploration of the Pacific Ocean," by Capt. Charles Phillipe Kerhallet, translated by Commander Chas. Henry Davis, U.S.N. Blunt, N. Y., 1861.

erally in a south-southwest direction. As it goes south it spreads considerably in such a manner that at its most southern part it runs through the whole chain of the Aleutian Islands, and is very strong in the channels formed by the islands."

The temperature of the two currents here described, so far as reported, ranges from 47° to 52°. The velocity of the Kamtschatka current is given at seven to ten miles north per day, and that of the Behring's current at five to nineteen miles south per day.

There is nothing in these authoritative statements that can be construed in favor of a rotating ocean. or afford any aid to the Gulf Stream theory. If any further evidence is needed on the first point, reference may be had to the surveys of Commodore (now Rear Admiral) Rogers, in 1855. These show that on the westerly side of Behring Strait, the current is almost invariably to the westward, and its force is stated at from one-half knot to one knot per hour. As regards the prolongation of the Gulf Stream, we suppose it will hardly be contended that it crosses the polar current; and it seems to us that this matter is effectually disposed of.

Fog or Ice-blink:—One of the most frequent and prevailing phenomena of the Arctic regions, reported by all explorers, is the fogs or ice-blink, which are as common over the surface of the sea as are clouds in the sky, and are the evidence of water and air of different temperatures. Ice-blink has been supposed by navigators as always to indicate the presence of open water and this no doubt is generally the case at all points reached by them. Capt. Beechey, in his experience in 1818, gives a very striking account of ice-blink, as he calls it, off the northwest coast of Spitzbergen, where there is often to be found considerable spaces of open water in the drifting ice-fields. A storm was raging at sea, but it did not reach his position and it was perfectly calm where his ships were lying. He says:—

"Over the ice the sky was perfectly cloudless, whilst the sea was overcast with storm clouds, which passed along until the line of the packed ice was reached. Here at the line of demarcation of the two atmospheres it was curious to mark the rapid motion of the clouds to the right and left, and how immediately they became condensed or were dispersed on arriving at it. The contrast between the two atmospheres is sometimes called ice-blink." [Beechey, p. 86.]

Dr. Kane's experience of ice-blink in Wellington Channel, October, 1850, is also peculiar:

"The brig and the ice around her are covered by a strange black obscurity, not a mist nor a haze, but a peculiar waving, palpable, unnatural darkness; it is the frost-smoke of Arctic winters. Its range is very low: climbing to the yard arm, some thirty feet above deck, I looked over a great horizon of black smoke and above we saw the heavens without a blemish."* [Kane's first voyage, p. 220.]

Capt. McClintock, February 2, 1859, records "a lovely, calm, bright day, except over the water space in Belloit Strait, where rests a densely black mist, very strongly resembling the West India rain squall as it looms upon the distant horizon." p. 20. Belloit Strait is in about lat. 72°, north of Boothia Felix, and wholly beyond the reach of the Gulf Stream. In similar cases the record is, almost constant fog excepting in very boisterous weather and heavy gales.

In speaking of the fogs, Capt. Hall found all his experience in the Arctic Regions or elsewhere at fault. He says—

"Before coming to the north, I thought I was prepared to give a fair statement of the true theory of fogs. I am satisfied that no man can give a satisfactory reason for the appearance and the sudden disappearance, their reappearance and final dispersion, as I have witnessed them during the last few days." [Hall's Arctic Expedition. Harper's edition, 1865.]

Capt. Hall's difficulty is only what others have experienced before him; it is the same as that which compelled Dr. Hayes to declare that "facts made mischief with his theories," and required Mr. Schott to account for the warm winds experienced by Dr. Kane by declaring that they "must have originated or blown over a water area partially open [?] of the temperature of 29°." The fogs, as Capt. Hall saw them, and as other explorers have seen them "throughout the year;" the thawing and tropic showers of Dr. Hayes, and the warm winds of Dr. Kane and others, are

* Something like this occurred in Boston harbor in Jan., 1866, and is described as follows:—

"The vapor is rising in clouds from the surface of the water in the harbor, and hides from sight the islands, and the shipping riding at anchor in the stream. The atmospheric mirage at early dawn was wonderful. The ice is forming rapidly in the harbor." [Boston, Jan. 8, 1866.]

Probably the same thing has often occurred at Boston. Ice smoke has been frequently observed by the writer on Charles river, driven over the surface of the ice with the wind.

certainly not to be explained on the theory of the Gulf Stream waters. Of course no "area of water partially open" can originate a wind which will make the "upper deck sloppy" and raise the temperature of the lower deck to 75°, as in the case of Capt. McClintock. The Gulf Stream itself removed bodily, so to speak, into the Arctic regions, could not produce such a temperature under the circumstances stated. The whole Arctic basin, if it were true that its waters are "never chilled to within several degrees of the freezing point" (29°), as asserted by an explorer while standing upon the icy border of the supposed open sea, "old ice" at that, could not produce such an atmosphere. In the tropical aerial currents only, it would seem, is to be found an adequate cause for these phenomena, and although the natural warmth of the sea and the low temperature of the atmosphere, may often produce ice-blink over considerable spaces, no such openings as reported can originate a warm wind or account for other known phenomena. Fogs and clouds are produced by atmospheres of different conditions, as regards temperature and humidity,* and the surplus humidity in the mass falls in the form of rain or snow. A tropical current, moving in the higher regions of the air toward the poles of the earth, as described by various writers, following approximately the lines of longitude, provides these atmospheres with heat and moisture, and answers all the conditions required, and makes possible, in fact inevitable, the remarkable phenomena of the Arctic regions. Nothing less than this, it seems to us, is adequate to account for these phenomena, so common and so constant "throughout the year."

We may add to what has been said, in confirmation of the views expressed, the experience of Dr. Hayes, in the North Fiord of Disco, lat. 70°, in August, 1860:

"In all my former experience in this region of startling novelties, I had never seen anything to equal what I witnessed that night. The air was warm, almost as a summer's night at home, and yet there were the icebergs and the bleak mountains. * * * The sky was bright and soft and strangely inspiring, as the skies of Italy. The bergs had wholly lost their chilly aspect," etc. p. 25.

"I awoke after a few hours, shivering with the cold. The bull's

* "The conditions under which the vapor of water becomes visible depend upon the temperature and the degree of saturation." [Flammarion, p. 417.]

"Fogs are clouds which float on the surface of the earth; and clouds are fogs in the higher regions of the atmosphere." [Dick., Atmos., p. 47.]

eye above my head was open, and a chilly fog was pouring in upon me. Hurrying on deck, I found the whole scene changed. A dense gray mist had *settled over the waters* and icebergs and mountains, blending them all in chaotic gloom." p. 26.

CLIMATE OF THE ARCTIC REGIONS:—The evidence of a modified climate and that in favor of an open polar sea—like the other oceans of the globe—at the present time appear to be conclusive; and these two points admitted, our preconceived notions of the general climate of the unknown region are at fault and no longer to be accepted. One of the earliest and strongest suggestions in this matter is that which resulted from the expedition of Sir Edward Parry in 1827, when he found himself surprised by the growing weakness of the ice, and annoyed by the frequent rains and the repeated changes from snow to rain which occurred during his sledge excursion. It may be said if this remarkable attempt to reach the region of the pole by sledges proved anything besides that of a drift to the south, it proved a modification of the climate as he progressed, and an ameliorated state of the atmosphere beyond the point reached. The weather and the temperature which he met and found, had they prevailed farther south, would have made an impression upon the great ice barrier; and it now seems have done so in subsequent years. But even prior to Capt. Parry's experience, the circumstance reported by Capt. Beechey, in 1818, of enveloping a vessel, sails and rigging, in ice during a snow storm off the north coast of Spitzbergen which changed to rain, was thought to be very suggestive, inasmuch as the air above must have been very much warmer than the air at the surface of the sea. Morton says, "After travelling due north over a solid area choked with bergs and frozen fields [just as Capt. Parry had done], I was startled by the growing weakness of the ice: its surface became rotten and the snow wet and pulpy." As he continued his journey "land ice and snow ceased altogether." Dr. Hayes had the same experience.

Capt. Parry found ponds of fresh water on the ice in lat. 82° 17′ 10″ which had been there a long time. Capt. Inglefield, in 1852, reached lat 78° 28′ 21″, in Smith's Sound and found an open sea. From appearances he inferred that he had reached a more genial climate than at Baffin's Bay. Instead of eternal snows which he had left behind him the rocks appeared in their natural color. In

Parry's voyage, having passed the winter at Winter Island, in 1822–3, he says, "Now we know that a winter in the ice may be passed not only in safety but in health and comfort." Capt. Hall in his last despatch to the Secretary of the Navy, Oct., 1871, lat. 82° 3′, long. 61° 10′ west, in Kennedy channel, says "We find this a much warmer country than we expected. From Cape Alexander the mountains on either side of the Kennedy channel and Robeson Strait were found entirely bare of snow and ice, with the exception of a glacier that we saw commencing in about lat. 80° 30′ north, on the east side of the Strait, and extending in an east-northeast direction as far as can be seen from the mountains by Polaris Bay. We have found that the country abounds with live seals, game, geese, ducks, musk oxen, rabbits, wolves, foxes, bears, partridges, lemmings," etc. Capt. Tyson, in the same vessel, describes the climate as being "distinctly milder than it is several degrees farther south," and gives other evidences of an ameliorated climate. The shore was free from snow and covered with herbage. Musk-oxen live in this region through the winter. "After passing the ice-barrier, which extends from the 70th to the 80th degree," reports a correspondent of the "London Times" of the Polaris voyage, "the climate became sensibly modified. Drift-wood from the northward was picked up, much decayed. Besides musk-oxen, rabbits and lemmings were abundant; one or two bears were seen, numerous birds from the south in summer, and wild flowers were brilliant." There was a marked difference between the two shores, the eastern being more favored in climate and vegetation as is the case throughout the Arctic regions.

There are many well established facts which appear to authorize the conclusion that there is beyond the well known ice-barrier, which encircles the polar sea, a region possessing a climate less severe than that directly south of it. The idea that the farther north we penetrate, and the nearer we approach the pole, the colder it becomes, natural enough in itself, is not true in point of fact. The poles of cold are within the range of the ice-belt, and they indicate the prevailing temperature of the region at the surface. Among the evidences of an ameliorated climate are those which relate to animal life in the highest points reached, not in the summer months alone but especially in the winter months. The accounts of the migration of birds to the north from various points are numerous and undisputed, and make certain the presence of

open waters of considerable extent. The appearance of animals in Greenland, Jan Mayen and Spitzbergen, in the winter months and early in the spring, furnishes irrefragable evidence that they remain in the higher parts of those countries during the year and live upon the products of the soil. In the attempts made to establish settlements at Jan Mayen in lat. 71°, bears appeared during the winter and were killed in February and March.

On the 10th of November the bears, "as appears to be their custom," says the record, became extremely numerous: the gulls did not quit the island during the winter, but had their nests in the mountains, to which they returned in the night. "The winter, though checkered with thaws and rains even in the coldest months, was occasionally very severe; and there was such an abundance of snow that it was often up to their arm pits, and sometimes wholly prevented their moving out of their house." [Beechey, p. 175.]

Capt. McClintock says "Peterson tells me that the Esquimaux of Upernavik are unable to account for the occasional disappearance and reappearance of immense herds of deer, except by assuming that they emigrate at intervals to feeding grounds beyond the glacier." Capt. Phipps, in July, 1773, speaking of the Seven Islands on the north coast of Spitzbergen, says the valleys were filled with snow, while reindeer were feeding on moss and scurvy-grass in the middle of the island, and birds were abundant. Capt. McClure, in his celebrated passage on the ice around the North American continent, says, "the hares and ptarmigan descended from the high ground to the sea ridges, so that a supply of game was kept up during the winter," by which fresh meats were had twice a week, besides the Christmas festival.

The mountains of Spitzbergen are reported to be bare or comparatively bare of snow. Capt. Beechey first speaks of them, on approaching the island, when "the dark pointed summits of the mountains, which characterize the island, rose majestically *above beds of snow.*" *Some of the mountains*, he says, "have smooth rounded surfaces; *upon several of which* the snow remains throughout the year." Vegetation is "found to a considerable height, so that we have frequently seen the reindeer browsing at an elevation of 1500 feet. This elevation, it will occur to many of my readers, must be above the region of perpetual snow," which De la Beche (Geology, p. 24) places at 450 feet. Again Capt.

Beechey says "we find mountains divested of their snowy covering at elevations far above the line at which perpetual frost may otherwise be presumed to exist; * * * * extensive tracts are sometimes seen perfectly bare at the height of 3000 feet." Morton also reported Mount Parry bare of snow, and it is almost certain that the mountains of Greenland, in the interior, are comparatively free of snow and the resort of immense herds of reindeer during the winter. The islands around Spitzbergen are reported to be high and precipitous, but covered with lichens and other rich pasturage for reindeer.

The Story of Spinks:—One of the most fearful and ultimately ludicrous incidents to a single individual in the Arctic regions happened to one of Capt. Buchan's sailors at Spitzbergen. It appears that Spinks had obtained permission, with a number of other seamen, to hunt deer upon the mountains near the coast, where they were feeding. Late in the afternoon a signal was made from the ship for all hands to return on board. Spinks was determined to be at the landing a little ahead of his companions, as was his custom on all occasions; and his promptitude and reliability made him a general favorite with his officers. Spinks started to go down the mountain, a slow and difficult process in the usual manner, and soon came to the upper edge of the snow. He here seated himself and prepared to slide down over the frozen surface, holding on by the heels of his boots, by which means he expected to check his speed in making the descent. But he soon found the crust too thick and firm for his boots to penetrate, and lost all control of his progress, going down the slope of two thousand feet with increasing velocity, and making the fine snow fly so as completely to envelop himself as in a cloud. In this condition he was seen from the ship and by the men on the beach, flying down the mountain with the speed of the wind, directly towards the perpendicular face of a glacier, two or three hundred feet high, fronting on the sea. To those who witnessed his descent his fate seemed inevitable; but by some means, unknown to any of the observers, his direction became slightly changed, and the fearful precipice of the glacier was escaped. He dashed over the brink of the mountain and was instantly buried many feet under the snow. As soon as possible he was dug out by his comrades, and when placed upon his feet started

on a run for the beach, having, as Sir Edward Beechey soberly declares, "worn through two pairs of trousers and something more," in his fearful descent. It may be interesting to know that after his return to England, Spinks was promoted to the office of gunner in His Majesty's service, and died some years later at Gibraltar—where he was buried with special honors by his officers and shipmates—one of the few sailors in the English navy whose name ever meets the public eye in print, much less finds a record on the pages of history.

RAINFALL:—There can be no doubt that frequent rains, like those already mentioned, fall upon the mountains, and probably throughout the vast water-shed, during the whole year; and that these in the valleys, as well as on the mountains, do more than the presence of the sun in dissolving the snow. It is equally certain that the melting processes throughout the Arctic regions, and more especially in their most northerly sections and mountainous countries, are not limited to what is called the summer season, or during the presence of the sun. In the summer the process is doubtless going on, partially at least, as described by Capt. Beechey, while in Magdalena Bay, Spitzbergen, in 1818:

"There is the most marked difference between the sides of the Bay, both in point of climate and general appearance: for while, on the one, *perpetual frost* is converting into ice the streams of water occasioned by the thawing snow upon the upper parts of the mountains which are exposed to the sun's rays, the other side is relieving itself of its superficial winter crust and refreshing a vigorous vegetation with its moisture." p. 48.

This process is very much aided, and likewise carried on in the absence of the sun and wherever the sun's influence may not reach, by the abundant rains. Scoresby mentions the fact that it rains nearly every month in the year. Hall mentions rain in Frobisher Bay, Dec. 22, 1860. Dr. Hartwig reports rain in Spitzbergen in January, and there are numerous similar statements.* In speaking of the melting ice, Prof. Tyndall says—

"Ice requires a great deal of heat before it melts. A layer of ice often becomes a protection against the cold. * * * * The

* In the Antarctic regions, Cordova, in 1774, says the summer months are seldom clear; no day passed without some rain falling and the most usual state of the weather was that of constant rain.

slowness with which ice melts is well known. During the winter of 1740, the Czar built, at St. Petersburg, a magnificent palace of ice, which lasted several years. Since then cannons have been made of ice, and have been loaded with balls and fired. They were fired ten times without bursting. It is, consequently, indisputable that ice melts slowly and may be turned to good account in the polar regions. In Siberia the window panes are made of ice." It has already been remarked that rain had a greater effect upon the ice than the presence of the sun, a statement which will not be controverted.

WARM WINDS, ETC.:—The climate of the Arctic regions, so far as our knowledge extends, is one of great variableness in respect of temperature, winds, storms and calms.* Beyond the ice-barrier, however, there is reason to believe it is one of more equanimity, resembling perhaps in this respect the temperate zone; but of course still subject to sudden changes. One of the strongest evidences of a warmer climate beyond the ice-barrier, if not in fact conclusive, is the warm winds which are reported all around the Arctic circle as blowing from the true north; which are in fact, what may be called the extension of the warmer northern climate to the south, sometimes it would seem to a very annoying extent.

Of course the southern limit of this modified climate cannot be defined. It may be different in different directions as well as at different times. The reported observations of Mr. Scoresby, Jr., are illustrative, although we do not regard them as authorizing the conclusion which he reached. From the observations of many years he found the temperature in latitude 78° as follows: May, June and July, average, 22°, 31° and 37° respectively; and for the whole year, 17°. He inferred from these that the average temperature at the pole must be 10° and therefore that such a thing as an open circumpolar sea was "chimerical." Since the time of Mr. Scoresby (1808 to 1818), we have gained more information and reached very different conclusions in regard to the temperature of the Arctic regions beyond the 78th parallel. From 1820 to 1873, we have been in the receipt of evidence, year by year, of a modified climate in the neighborhood of the pole, shown by almost every

* Sir Edward Belcher says:—
"Climate and winds differ here so widely within a space of ten miles, that it is quite impossible to calculate on the weather they may experience." p. 245, vol. I.

species of testimony connected with physics, meteorology and natural history. This climate no doubt told upon his statistics, which indicate a remarkable equanimity during the whole year, the average of the year differing from that of the warmest month only twenty degrees. Of this region, it may be said, and has been said of Siberia, "as under the tropics there are only spring and summer, so in the north there are only summer and winter."

We annex some further evidence upon this subject and the conclusion of the whole matter seems to be inevitable that there is an open sea in the region of the theoretic pole and that it is approachable and can be reached; and the argument goes far *to confirm the reports of the Dutch navigators that they have several times reached and sailed around the position of the pole, in latitude* 88° *and* 89°.

EVIDENCE OF AN AMELIORATED CLIMATE:—August 18, 1821. "Nothing could exceed the fineness of the weather about this time; the climate was indeed altogether so different from that to which we had before been accustomed in the icy seas, as to be a matter of instant remark." [Parry's 2nd voyage, p. 203.] "The days were temperate and clear and the nights not cold," though thin ice formed in sheltered places.

Oct. 24. "The wind veering to the S. E. on 24th and 25th, the thermometer gradually rose to +23°. I may possibly incur the charge of affectation in stating that this temperature was much too high to be agreeable to us; but it is, nevertheless, the fact that everybody felt and complained of the change." "From −40° up to zero is welcome, but from zero to 32° is rather an inconvenience." [Parry, p. 239.]

Oct. 10 to 21, 1850. A rise of temperature from −2° to +20° with wind northeast. This sudden change was far from pleasant to the crew and the old hands warned the novices against "being fools enough to pull off their clothes on account of such a bit of sunshine, for perhaps in an hour's time zero would be about again." [McClure in Sargent, p. 363.]

"The sky of Baffin's Bay, though but 800 miles from the polar limit of all northness, is as warm as the bay of Naples after a June rain. What artist, then, could give this mysterious union of warm atmosphere and cold landscape?" [Kane i, p. 149.]

1853. Dec. "Our anticipations of decrease of temperature

were in this instance groundless, as with the increase of wind it rose rapidly to $+25°$. Aloft it evidently blew a heavy gale, of which we were merely entertained with the whistling and rattling of our loose gear atop." [Belcher, "Last of the Arctic Voyages," p. 85.]

"At Bear Island, beyond Icy Cape, in latitude 74° 30′, great mildness of climate was experienced by some seamen who passed the winter of 1823–4, in this locality; they encountered no severe cold nor saw either packed or floating ice." [Ann. Sc. Dis. 1853, p. 393.]

Capt. Richard Wells, of steamship Arctic of Dundee, in a letter to Mr. Grinnell, 1867, says he continued to the "north until he opened out Smith Sound, Humboldt glacier being in sight through the glass from the mast-head." There was no indication of ice to the northward; sky blue and watery and only a few small streams of light ice to be seen; then in about 79° as he judged. He adds, "I believe that had we not been on a whaling voyage, we should have met with no difficulty in attaining to almost any extreme northern latitude."

"Within the Arctic circle there are countries inhabited as high nearly as we have discovered; and if we may confide in the relations of those who have been nearest the pole, the heat there is very considerable, in respect to which our own navigators and the Dutch perfectly agree." [Barrington's Miscellanies, London, 1581, p. 65–6.

Precipitation:—It seems hardly necessary, after what has been said, to refer to Prof. Rogers' statement on this subject from the work already quoted, and we should omit to do so but for the fear that the statement may be accepted as true. In speaking of the great water-sheds of Asia and America, Prof. Rogers says:

"But through a large portion of the year the precipitation does not flow off, but remains frozen on the surface until the sudden arrival of summer sets the whole mass free; then, augmented by the summer rains, the entire annual accumulation pours off, during a few weeks, into the polar sea."

Prof. Rogers could hardly have seen, it seems to us, the full meaning of this statement. Such a condition of things, we venture to say, under the circumstances, is impossible, and is at variance with all we now know of the Arctic climate, summer or

winter. The idea that the accumulations of a large part of the year could flow off in a few weeks is not to be credited. Whatever the accumulations of snow and ice may be, the outflow of the ocean is never checked, and drift ice is always to be met with. The rainfall is very great, as we have already shown, and it is reported as melting the ice more rapidly than the heat of the sun, even in summer, and rain is reported in every month in the year in Spitzbergen, Greenland and Jan Mayen, and occurs, no doubt, in all the glacial regions. So that while the rains melt the ice at and near the surface, they also melt the snow that falls upon the tops of the mountains and contribute largely to the formation of glaciers; and in this way a vast amount of the rainfall and accumulations of ice pass out of the Arctic Regions in the form of icebergs, which are dissolved in the ocean.

RECENT INTELLIGENCE.—The most recent intelligence from the Arctic regions,—that received by the party from the Polaris, of Capt. Hall's expedition, is of very interesting character, and while it throws into the shade some of the results of former expeditions, confirms the most important features of them and adds considerably to our reliable knowledge of the character and geography of those regions. Capt. Hall, it is generally admitted, was able to reach with his vessel up Kennedy Channel, a higher latitude than was attained by Dr. Kane or his successor, Dr. Hayes, by sledges, or any other navigator in the same direction, namely, 82° 16′. He went beyond the open sea of Morton and the "iceless ocean" of Dr. Hayes, and ascertained that what they saw is merely an expansion of Kennedy Channel, with Washington Land and Grinnell Land on either side of it, still extending to the north free of ice. On the eastern side of the channel Capt. Hall found a bay or inlet twenty miles wide, which it was thought might prove to be the northern coast line of Greenland. The precise latitude of this inlet is not given, and it is very probable that it is the same strait discovered by Capt. Inglefield, in the steamer Isabel in 1852, and named by him Murchison Strait. He places it in latitude 77° 30′ and likewise supposed it to form the northern limit of Greenland. Capt. Inglefield saw the open sea stretching, as he supposed, at least to latitude 80°, but was prevented by a heavy gale from sailing farther into it. North of this inlet in latitude 81° 38′, Capt. Hall locates Polaris Bay, in which he passed the winter of 1871,

beyond the highest point reached by his predecessors. The land on the eastern shore of the channel trends to the northeast as far as Repulse Harbor, latitude 82° 9′, the highest point reached by land, and that on the west shore appeared to terminate in a head-land in latitude 84°. These evidences of the extension of the land towards the north, it will be seen, essentially reduce the size of the open sea and leave us in the dilemma of a recent writer, who, almost on the same page, declares that there is no assignable reason for the supposition that Greenland extends to the pole, and none to conjecture that Ellesmere Land does not so project.

CONCLUSION.—In concluding this discussion we may congratulate the Association that, after more than three hundred years of exploration and effort, we have reached, it is to be hoped, an approximation to the truth in regard to these interesting regions; and although we cannot claim for our country that it was among the early laborers in this field, we may point to our efforts, our achievements and the results attained, with pride and satisfaction. It belongs to England to say that her brave and courageous navigators have circumscribed, if not circumnavigated, the North American continent; and to her also, as yet, the further honor of having made (in modern times) the nearest approach to the pole in the person of her noble son, Sir William Edward Parry. Nevertheless, the labors of Kane and Morton, Hayes and Hall, have added much to our knowledge of the Arctic regions; and it would seem, by their discoveries and explorations more clearly than ever before, have opened the way to that mysterious polar sea which has been so long the object of such laborious and perilous effort, and of such absorbing interest.

CORRECTION.—In the Dubuque paper on this subject, vol. xxi of the Proceedings, the reader is requested to strike out the word "thousand" on p. 112, 21st line, probably an accidental interpolation of the compositor (as it is not in the manuscript), unfortunately not detected by the proof reader, and, as it stands, a most egregious error of statement.

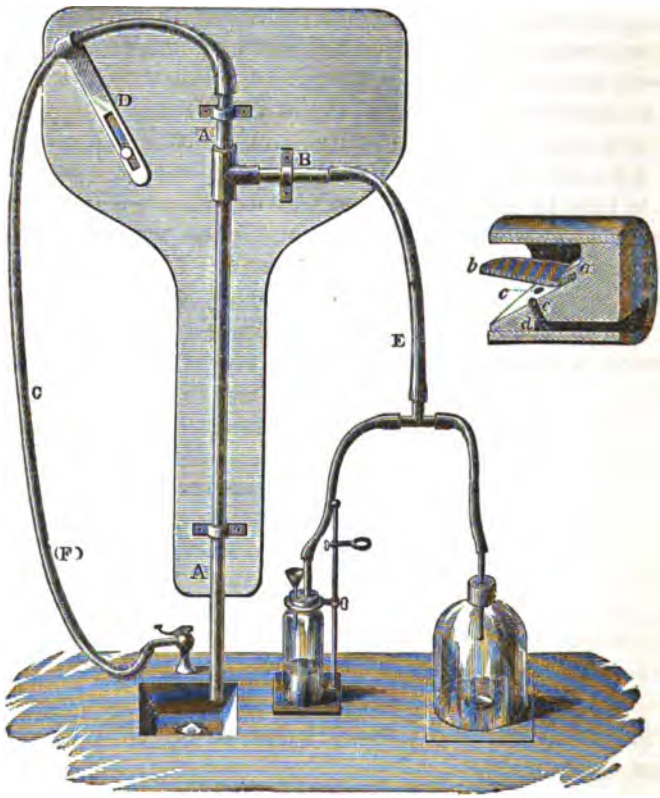
A MODIFICATION OF THE VACUUM OR FILTER PUMP, THAT CAN BE USED WITH FROM THREE TO FIVE FEET FALL OF WATER AND DOES NOT EASILY GET OUT OF REPAIR. By A. E. FOOTE, of Ames, Iowa.

THE introduction of the Sprengel vacuum or filter pump, so widely known by the commendation that it received from Prof. Bunsen, was limited by the fact that most laboratories did not possess the necessary fall of water.

The discovery by Jogno, in 1872, of the vibrating tube and valve will not only widely extend the use of the filter pump, but also afford a substitute for the cumbersome original form. In attempting to introduce Jogno's apparatus, I, together with many others, found that there were several defects to be overcome. Among these the worst was that the valve became stiff after a short period of use, getting out of order and working imperfectly if at all. To obviate this difficulty Prof. T. E. Thorpe devised a new form of valve, a description of which was read before the British Association last fall. An abstract of this paper may be found in the "American Journal of Science and Arts" for April, 1873. Thorpe's valve is difficult of construction, works very badly unless perfect and soon wears out. The device that I present for your consideration is exceedingly simple and easily constructed, since it can be made of common materials by any plumber or worker in iron. It has been in use in our laboratory for some time and we easily produce by it a vacuum of twenty-six inches of mercury.

The following is a description of the apparatus as modified by myself. A A is a tube three feet or more in length and from three-eighths to one inch in diameter; to the side of this, by means of a T, an arm B is affixed. This arm is from four to eight inches in length and may have a manometer tube attached. C is a caoutchouc vibrating tube which conducts the water to A. The upper end of A, over which it is thrust, is cut off at an angle of about 40°. The vibrations are regulated by an arm D. To B, is attached a rubber tube E which leads to the vacuum bell jar or bottle. Within B and at or near its connection with A, is fixed by cement the valve represented in Fig. 2. This is constructed as follows: the end of a metal plug is filed off as represented in Fig. 2, leaving a tongue of metal in the centre, which is driven down upon a flat of thin

sheet caoutchouc, holding this upon the holes, which penetrate the plug and communicate with a channel filed on the lower side of the plug as represented. The holes, in order to be perfectly closed by the flap, must be at least one-sixteenth of an inch in diameter. A clamp placed upon E and used to retain the vacuum may also



be made to regulate the rapidity of filtration or evaporation; this may be done more economically by means of a stopcock F, inserted in C to regulate the flow of water.

I have been led thus fully to detail this piece of apparatus from the belief that, as soon as known, its simplicity, compactness, efficient working and cheapness of construction will cause its general introduction in laboratories even where a fall of thirty feet of water can be obtained without difficulty. Its value, not only for

rapid and difficult filtrations, but also for evaporations where the application of heat is objectionable, cannot be overestimated.

I take pleasure in acknowledging my indebtedness to Prof. Alexander Thomson for much aid, especially for the mechanical execution of the work and the drawings that accompany this article.

In this connection a simple piece of apparatus, devised by one of our students, deserves mention on account of its simplicity, convenience and efficiency. It is ample for all filtrations where but a slight vacuum is needed. To the top of the shelving above the table and sink, fasten a tube (rubber). Connect one end of this with the water supply pipe, the other with the bulb of a thistle tube by means of a glass tube inserted in a rubber cork; through another hole in the rubber cork carry a tube which is connected with a large vacuum bottle. The vacuum produced will be proportional to the column of water supported in the thistle tube and its connections. The waste water is, of course, allowed to flow into the sink.

THE CHEMICAL COMPOSITION OF A COPPER MATTE. By T. STERRY HUNT, of Boston, Mass.

ABSTRACT.

THE name of matte or regulus is given to a product obtained in smelting partially roasted sulphuretted copper ores, and consisting in great part of sulphur and copper; it is the result of a process of concentration. A specimen of this, holding forty-five per cent. of copper, beside iron and sulphur, was found to give up the greater part of its iron to dilute acids, with the escape of free hydrogen and sulphuretted hydrogen gases. It precipitated metallic copper and metallic lead abundantly from their neutral solutions, and contained apparently the greater part of its iron in a metallic state. When oxidized by nitric acid or by bromine, it left a residue of more than ten per cent. of grains of pure magnetic oxide

of iron, and the dissolved portion contained about thirteen equivalents each of copper and sulphur, besides eight of iron and a little zinc. It was, as might be expected, strongly magnetic.

The author insisted upon the apparent anomaly exhibited in the association in a furnace-product of a stable oxide of iron with a sulphuret, the affinities being curiously balanced in the fused mass. The presence of metallic iron at the same time he explained as the result of a partial dissociation of a double sulphuret of copper and iron on cooling. His inquiries in this matter are not yet finished, but throw an unexpected light on some furnace-reactions, as the tréatment of iron in the Bessemer process, and also on the production in nature of many igneous and volcanic rocks.

DETERMINATION OF TRANSATLANTIC LONGITUDES. By J. E. HILGARD, of Washington, D. C.

[Communicated by permission of Prof. Benjamin Peirce, Supt. U. S. Coast Survey.]

THE exact determination of the longitude of some point in the triangulation of the Coast Survey, from the principal observatories of Europe, forms one of the most important problems of that work, and all the various means known to science have been successively brought to bear on its solution. The Coast Survey Reports from 1848 to 1866 show that the methods of moon-culminations, of chronometer transportation and of lunar occultations, have each in turn received a large share of attention. The latter method has not yet yielded the full results that may be expected of it, in consequence of the infrequency with which corresponding observations are obtained in Europe and America, owing to the parallactic displacement of the moon; it cannot be doubted, however, that with a suitably organized system of observation, this method will, in time, give results of great exactness.

Upon the successful completion of the Atlantic telegraph from Ireland to Newfoundland, measures were at once taken to make use of that means for the determination of the longitude between the two continents. The results of these operations, conducted

by Dr. B. A. Gould, have been given at length in the Report for 1867. Although far more certain than the previous results, the value thus obtained still left a larger margin of doubt as to its precision, than is desirable in so fundamental a determination. This uncertainty, which probably does not exceed one quarter second of time, is owing in part to the fact that, though we can measure the total time of transmission of signals through the cable and back again, we are unable to separate the duration in opposite directions and are obliged to assume it equal, an assumption which may not be exact within a sensible fraction of a second.

When the laying of the French cable, from Brest in France to Duxbury in Massachusetts, afforded an independent means of verifying the former result by observations under entirely different conditions, the opportunity was promptly seized, and the longitude between Brest and Duxbury determined by G. W. Dean, Assistant in the Coast Survey, as set forth in the Report for 1870.

At this time, no cable was yet in operation between Brest and England, so that Mr. Dean was unable to carry his determination direct to the Observatory at Greenwich. Such a cable having since been laid, the wanting link in the chain of longitudes was supplied, during the past summer, by J. E. Hilgard, Assistant in the Coast Survey, who temporarily gave up the charge of the Coast Survey Office, in order to bring this much desired operation to a satisfactory conclusion. While reoccupying Brest for that purpose, it appeared in every way desirable that the experiments through the French cable should be repeated; this time with an intermediate station at St. Pierre, where the long cable makes a landing. That part of the operations which connected St. Pierre with Cambridge was under the immediate direction of G. W. Dean.

The general plan of operations was to unite at Brest, signals from St. Pierre, from Greenwich and from Paris, sent nearly at the same time and compared by means of the Brest chronograph; and to determine the personal equations of the several observers through one of them, who should observe successively with all the rest. This was done by Sub-assistant F. Blake, Jr., who ably assisted Mr. Hilgard throughout the work. Through the kindness and assistance of Sir George B. Airy, the Astronomer

Royal of England, and of Mr. Delaunay, the distinguished Director of the Paris Observatory, whose lamented death occurred while the operations were in progress, and through the generous courtesy of the French Atlantic Telegraph Company, and of the Submarine Telegraph Company, the work was brought to a successful conclusion in the month of September, 1872.

In the course of these operations the longitude between Paris and Greenwich has been incidentally determined in two different ways; first, in July, *via* Brest, and afterwards, in September, between Greenwich and Paris direct, through the "Submarine" cable *via* Calais. These two determinations are not entirely independent of each other, since the personal equation between Blake and the Paris observer enters into both, but the near satisfaction of the equation (Brest—Paris + Paris—Greenwich + Greenwich—Brest) = 0, or the closing of that longitude triangle, must entitle the results obtained to great confidence.

We now proceed to give some account of the instruments and methods, before reciting the principal results.

Brest—Greenwich—Paris.

The station at Brest was chosen on the *place d'armes* in front of the Transatlantic Telegraph Company's Office, with which it was connected by wires. It was found to be 8·46″ south and 0·44ˢ east of the tower of St. Louis church, a point in the trigonometrical survey of France.

The instruments used were a transit instrument by Simms, of 45 inches focal length, and 25 inches transit axis, with a diaphragm of 15 lines; a circuit-breaking chronometer by Bond, and a Bond chronograph.

The plan adopted for determining the clock corrections provides for observations in both right and left position of the transit telescope, a set in each position comprising five time stars and two circumpolars, one above and one below the pole. By this system it is practicable to deduce the azimuthal deviation of the instrument independently for either position, and even to arrive at a fair value of the collimation, when observations have been obtained in but one position.

A careful determination of the inequality of pivots was made

by a series of levelings, and the corrections found to be due were applied in the reduction of the observations.

The chronometer is fitted with a circuit-breaking attachment by which the current is interrupted for an instant every two seconds and likewise at the fifty-ninth second, to mark the minute. In order to avoid the inconvenience arising from the deflagration of contact surfaces, by the spark developed at the break, a branch circuit, including a resistance-coil, was introduced according to the device of Mr. Hilgard, bridging the break, and permitting the ready passage of the secondary current, while the resistance is too great to affect sensibly the recording magnet.

It will be observed that the rate of this chronometer was not only determined by the observations made at Brest, but was also checked by daily comparisons with the clocks at Paris and Greenwich. Its performance was very satisfactory.

The observations of star transits and the time scale were recorded on the chronograph with the same pen, whereby any correction for relative position of the pens or styles is avoided, and the reading much facilitated.

At the Paris Observatory the general arrangements for the work were committed to Mr. Loewy, who lent a most cordial co-operation to our work. The chronographic method of recording time observations, not then in ordinary use at the Observatory, was adopted for the present occasion, and the assistant astronomer, Mr. L. F. Folain, who made all the corresponding observations, devoted a fortnight to preliminary practice with the new method, so as to obtain a settled habit of observing. The large transit instrument (*lunette méridienne*) was employed for the work, which was prosecuted with the greatest assiduity. The instrument was reversed twice on each night, and two complete sets of observations were made, each comprising eight stars in each position of the instrument, beside circumpolars and micrometer readings on the meridian mark.

After completing the observations at Brest, Mr. Blake transported his instruments to Paris and mounted his transit on a pier that had been provided for the purpose, a short distance to the south of the observatory transit, very nearly in its meridian, in the garden. Each observer now determined the time with his own instruments and after his own method, and compared the time-

keepers in the same way as had been done between Brest and Paris; the personal equation thus obtained including all peculiarities that may arise from instrumental causes.

At Greenwich the regular routine of observing was followed, as described in the Greenwich observations, the observers changing in a certain rotation, two observers generally determining the clock corrections on each day and their observations being referred to a common standard by the personal equations derived from the comparisons thus obtained.

When Mr. Blake, after completing the work at Paris, went to Greenwich for the purpose of comparing his personal equation with that of the Greenwich observers, his transit was mounted on a pier erected for the purpose by order of the Astronomer Royal, and again observed in his accustomed way, comparing his timekeeper telegraphically with the Greenwich clock and likewise with that at Paris, where Mr. Folain was still keeping up his corresponding observations. The Coast Survey party are specially indebted to Mr. William Ellis, who, under the direction of the Astronomer Royal, aided them in every way in the prosecution of the work.

The place of the pier, which has since been marked by a slab of marble bearing the inscription "*Hilgard*" is $0{\cdot}160^{s}$ west and $1{\cdot}74''$ south of the Greenwich transit circle.

The method of exchanging signals was by means of arbitrary signals sent over the line and recorded on the chronograph at each station. These signals were sent for five minutes at approximate intervals of five seconds, but the intervals were purposely varied so as to give different fractional readings. At eleven, P. M., Greenwich began sending to Brest, then Brest sent to Greenwich, next Brest to Paris and finally Paris to Brest. Between Greenwich and Brest but one series of signals was exchanged on each night, as the free use of the cable could not be granted for more than ten minutes. Between Brest and Paris, however, a wire was placed at the disposal of the party from eight, P. M., for the night and, in general, two series of exchanges were obtained.

The observations of Mr. Blake have been reduced in the following manner. The chronograph sheets having been independently read by two persons and readings collated, each evening's work was reduced by Mr. Blake, on the plan of deriving the colli-

mation and the azimuthal deviation of the instrument from all the observed stars by means of the usual normal equations, giving equal weight to all the stars—the clock correction being finally determined from stars within 60° declination, omitting the circumpolars, by applying the instrumental corrections previously obtained. In a more elaborate second computation made by R. Keith, each conditional equation was affected by a weight depending upon the star's declination according to a law derived from the observations themselves, and moreover separate values for the azimuthal deviation, before and after reversal, were deduced. The resulting clock corrections, obtained by the two methods of reduction, show a very good agreement, the average difference being only $0{\cdot}017^s$; the sum of the residuals for each star is less in the second than in the first in the ratio of twenty-six to thirty-one; but it should be observed that in consequence of the introduction of four instead of three variables in the equation, the observations should be better represented in something near that ratio, and only a small improvement can be ascribed to the use of weights. This matter will be found more fully discussed in the Coast Survey Report for 1872, when the observations of the American party will be given in full. Those made at Paris and Greenwich will be found in the regular publications of those observatories.

The right ascensions used in these reductions are a mean of those of the Washington Observatory from 1862 to 1867, and of the Harvard College Observatory from June to November, 1872. They do not agree precisely with either the Greenwich or the Paris right ascensions, but the differences are small. It would certainly have been desirable to use the same data in the reduction of the observations at all stations, but as Greenwich and Paris do not agree in their standard places, it was thought best to use the list adopted for the Coast Survey work and let the accidental variations be merged in the errors of observation, while any systematic difference in the places would form part of the personal equation. The longitudes cannot, in any sensible degree, be affected by the differences adverted to.

We will now give a table of chronometer corrections, as deduced by the second method of reduction, to show the performance of the timekeeper, followed by a specimen of one night's work, and finally a tabular statement of the results for longitude.

Corrections of chronometer Bond, No. 380, at 18h., S. T., from observations by F. Blake, Jr.

Place.	Date.	Correction.	Hourly rate.
Brest.	July	s	s
	1	+3·741	—·018
	3	+2·750	·019
	4	+2·370	·018
	5	+1·953	·018
	9	+0·049	·020
	11	—0·933	·024
	12	—1·651	·029
	14	—2·139	·010
	17	—2·803	·009
	18	—3·054	·010
	19	—3·010	·002
	20	—3·261	·008
	21	—3·391	·009
	22	—3·702	·012
	23	—4·053	·015
Paris.	August		
	16	—1·470	+·006
	17	—1·322	—·001
	18	—1·348	·002
	19	—1·382	·006
	20	—1·530	·006
Greenwich.	August		
	28	+1·725	+·004
	30	+1·895	·013
	31	+2 205	·007
	3	+3·706	·017
	4	+4·109	·015
	5	+4·469	·021
	6	+4·945	·023
	7	+5·508	·030
	9	+6·885	·030
	10	+7·630	·031

Brest, July 5, 1872. Observer F. Blake, Jr.

Star.	L.	Observed time of transit.			Corrections.		
					Level.	Azim.	Coll.
		h.	m.	s.	s.	s.	s.
μ' Bootis............	E	15	19	39·05	—·14	+·01	+·05
α Cor. Bor..........			29	15·65	—·11	+·01	+·05
ζ Ursa Minor.......			48	43·61	—·37	—·06	+·22
τ Herculis...........		16	15	53·70	—·08	+·00	+·07
η Draconis..........			22	16·42	—·13	—·01	+·10
A Draconis..........	E		28	15·92	—·19	—·02	+·13
9 Camelop. L. C.....	W		41	16·85	+·07	—·30	+·18
κ Ophiuchi..........			51	36·58	—·03	—·09	—·07
d Herculis...........			56	53·03	—·02	—·04	—·09
α' Herculis...........		17	8	48·58	+·00	—·08	—·08
ω Draconis..........	W		37	44·02	+·00	+·13	—·20

Star.	L.	Time of Meridian Transit.	Right Ascension.	Clock Corrections.
		h. m. s.	h. m. s.	s.
μ' Bootis............	E	15 19 38·97	15 19 40·92	+1·95
α Cor. Bor..........		29 15·60	29 17·65	2·05
ζ Ursa Minor.......		48 43·40	15 48 45·43	2·03
τ Herculis...........		16 15 53·69	16 15 55·67	1·98
η Draconis...... ...		22 16·38	22 18·33	1·95
A Draconis..........	E	28 15·84	28 17·82	1·98
9 Camelop. L. C....	W	41 16·80	41 18·60	1·80
κ Ophiuchi		51 36·39	51 38·38	1·99
d Herculis...........		56 52·88	56 54·80	1·92
α' Herculis...........		17 08 48·42	17 08 50·52	2·10
ω Draconis..........	W	37 43·95	37 45·68	1·73

Clock correction at 16h·4. Sid. T. +1s·982.
Collim. = —·056. Azimuth for Lp. E. +·025; for Lp. W. —·132.
The first reduction, without weights, had given clock correction +1·986, collimation —·040, azimuth —·077.
The "observed time of transit" is the mean of fifteen threads.

TELEGRAPH SIGNALS BETWEEN BREST AND GREENWICH.

July 5, 1872.

Greenwich to Brest.	m. s.	*Brest to Greenwich.*	m. s.
Difference, mean of 30 signals,	+17 11·101	Difference, mean of 30 signals,	+17 11·134
Correction of Brest clock,	— 1·950	Correction of Brest clock,	— 1·948
Correction of Greenwich clock,	+ 47·900	Correction of Greenwich clock,	+ 47·900
Longitude — Signal time,	+17 57·051	Longitude + Signal time,	+17 57·086
Mean,	+17 57·068	Signal time,	0·018

TELEGRAPH SIGNALS BETWEEN BREST AND PARIS.

July 5, 1872, 1st Exchange.

Paris to Brest.	m. s.	*Brest to Paris.*	m. s.
Difference, mean of 30 signals,	+27 40·843	Difference, mean of 30 signals,	+27 40·933
Correction of Paris Clock,	— 20·570	Correction of Paris clock,	— 20·574
Correction of Brest Clock,	— 1·995	Correction of Brest clock,	— 1·990
Longitude — Signal time,	+27 18·278	Longitude + Signal time,	+27 18·369
Mean,	+27 18·323	Signal time,	0·046

July 5, 1872, 2nd Exchange.

	m. s.		m. s.
Difference, mean of 30 signals,	+27 40·833	Difference, mean of 30 signals,	+27 40·949
Correction of Paris clock,	— 20·601	Correction of Paris clock,	— 20·602
Correction of Brest clock,	— 1·958	Correction of Brest clock,	— 1·957
Longitude — Signal time,	+27 18·274	Longitude + Signal time,	+27 18·390
Mean,	+27 18·332	Signal time,	0·058

RESULTS OF OBSERVATIONS FOR PERSONAL EQUATION.

Paris.

Blake, west of Folain, August	16,	s. −0·135
	17,	+0·075
	18,	+0·193
	19,	+0·076
	20,	+0·054
Blake, west of Folain, mean,		+0·053 ± 0·037

Greenwich.

Coast Survey Station reduced to Transit circle.

Reduction, −0·16 s.

Date.	Blake east of observer.	Reduction to standard observer.	Blake east of standard observer.
	s.	s.	s.
August 28	J. C. +0·070	+0·010	+0·080
30	L. +0·427	−0·240	+0·187
31	E. −0·124	+0·230	+0·106
September 3	H. C. −0·001	0·000	−0·001
4	L. +0·365	−0·240	+0·125
5	J. −0·025	+0·060	+0·035
6	J. C. −0·050	+0·010	−0·040
7	Std. +0·005	0·000	+0·005
9	E. −0·117	+0·230	+0·113
Blake east of Greenwich standard observer, mean			+0·068 ± 0·016

LONGITUDES.

Brest—Greenwich.

	m.	s.
July 1,	17	57·149
3,		57·124
4,		57·120
5,		57·068
11,	17	57·026
Mean,	17	57·097 ± 0·015 s.
Personal Equation,		+0·068 ± 0·016
Difference of Longitude,	17	57·165 ± 0·022

Brest—Paris.

	m.	s.
July 1,	27	18·232
3,		18.266
4,		18·192
5,		18·328
9,		18·359
19,		18·186
20,		18·331
21,		18·207
22,	27	18·166
Mean,	27	18·252 ± 0·016 s.
Personal Equation,		−0·053 ± 0·037
Difference of Longitude	27	18·199 ± 0·039

Greenwich—Paris.

	m. s.
August 28,	9 21·020
31,	21·009
Sept. 7,	21·052
9,	20·914
10,	21·006
Mean,	9 21·000 ± 0·016
Personal Equation,	—0·053 ± 0·037
Reduction to Greenwich transit,	+0·160
Difference of Longitude	9 21·107 ± 0·039

The results of the first computation were as follows:

	m.	s.
Brest—Greenwich	17	57·124
Brest—Paris	27	18·176
Greenwich—Paris	9	21·116

differing but very little from the preceding values.

The sum of the values Brest—Greenwich + Greenwich—Paris exceeds the direct determination Brest—Paris by 0·073ˢ, which is within the limits of the assigned probable errors. If we now distribute this residual among the three values, without regard to weights, and omit the thousandths of seconds, we shall find as the resulting longitudes:

	m.	s.
Brest—Greenwich	17	57·14
Greenwich—Paris	9	21·08
Brest—Paris	27	18·22

It appears that the uncertainty of any of the above values does not probably exceed 0·03ˢ. If we compare them with other determinations heretofore made, we find that Brest—Paris was determined telegraphically in 1863, under the direction of Mr. Le Verrier, when the longitude of the "*tour de St. Louis*" from the "*méridienne de France*" (the centre of the Paris observatory) was found to be 27ᵐ 18·49ˢ (Annales de l'Observatoire de Paris, viii, 1866, p. 279). In order to reduce our own result to the same point of reference, we must deduct 0·12 at Paris and add 0·44ˢ at Brest, whence we obtain 27ᵐ 18·54ˢ, differing but 0·05ˢ from that found by the French operations, which were very elaborate and are published in full; or if we compare with our direct determination, the difference is only 0·03ˢ.

The longitude between the observatories of Greenwich and Paris was determined in 1854 at the instance of Mr. Le Verrier. The result then obtained, $9^m\ 20{\cdot}63^s$, which is nearly half a second less than that resulting from our recent work, has ever since been accepted, but the Paris observations, upon which it depends, have never been published. Partly owing to this fact, and partly because in those operations the chronographic method was not used, the Central European Geodesic Association had, at its session at Vienna, in the autumn of 1871, expressed the wish that it should be redetermined. In pursuance of this expression, Mr. Delaunay had already entèred into correspondence with Mr. Airy when the American party came into the field and, desiring to refer their longitude to each observatory independently, obtained leave to determine the difference between the same as an incidental part of their operations. It is to be presumed that another determination will be made before long to verify this important datum.

Another combination of the results may be made in the following manner. Remarking that on four occasions observations were had at Greenwich, Brest and Paris on the same evenings, we may deduce the longitude Greenwich—Paris directly, without using the observations at Brest, when we obtain

	m.	s.
Greenwich — Paris, July 1	9	21·083
" " " 2		·142
" " " 3		·072
" " " 4		·260
Mean	9	21·139
Personal equation		—·121
Longitude	9	21·018

The personal equation here applied is that between Folain and the Greenwich Standard Observer as derived through Blake, viz.: ·053 + ·068, as previously given in detail. Combining the result of these four nights with that of the five when Blake observed at Greenwich, viz.: $9^m\ 21{\cdot}107^s$, we get Greenwich—Paris $9^m\ 21{\cdot}07^s$.

Combining farther the two determinations Brest—Paris (1872), 27^m 18·20, Brest—Paris (1863), $27^m\ 18{\cdot}17^s$ and Brest—Greenwich (1872), $17^m\ 57{\cdot}16^s$ with the foregoing, we shall obtain, as the most probable values that can be assigned,

	m.	s.
Brest—Greenwich	17	57·14
Greenwich—Paris	9	21·06
Brest—Paris	27	18·20

Brest—St. Pierre—Cambridge.

It was intended that the observations at and exchanges of signals between the American stations should be as nearly simultaneous with those in Europe as the weather might allow, in order that the intermediate stations at Brest and St. Pierre should sensibly disappear from the determination of the longitude of Cambridge from Greenwich and Paris. Such simultaneous operations proved, however, to be impracticable in consequence of the condition of the cables. The long cable between Brest and St. Pierre was working badly, and required to be repaired before it was fit for our use. When this was accomplished it proved to have a better insulation than ever before, and transmitted the signals with great sharpness. Meantime the cable between St. Pierre and Duxbury had been broken and could not be repaired during the summer, in consequence of which our arrangements required to be changed. Mr. Dean, who had charge of the American part of the operations, at once proceeded to make arrangements for exchanging signals between St. Pierre and Cambridge over the Nova Scotia and New Brunswick telegraph lines, connected with St. Pierre by a short cable, and working with ordinary Morse registers, so that this part of the work offers no unusual features, the signals being registered automatically on the chronograph. The signals sent through the Brest-St. Pierre cable, on the contrary, were observed by means of the Thomson galvanometer, as heretofore described in the account of the 1867 longitude operations by Dr. Gould. The cable was working so well that no special battery or signal arrangements were required, a single current at intervals of five seconds giving a very sharp movement of the index, which returned to its zero before the next signal was sent. The personal equation of each observer, in perceiving and recording these signals upon his chronograph by tapping a key, was frequently determined by means of a short circuit, and was found to be very constant for each observer as well as nearly equal for both. For Blake at Brest it was $0{\cdot}24^s$, and for Goodfellow at St. Pierre $0{\cdot}23^s$.

The station at St. Pierre was in charge of Mr. Edward Goodfellow, Assistant in the Coast Survey, who had taken part in the two previous determinations of transatlantic longitude by cable. All the observations were made by himself. The observer at Cambridge was Mr. Edwin Smith, of the Coast Survey. The

instrument was mounted on a pier, one hundred and eight feet to the west of the observatory dome, to which our longitudes are usually referred, requiring a reduction of 0·096ˢ. Three piers were built in this temporary observatory, permitting the three transit instruments used in the expedition to be mounted in the same meridian at one time. This was done after the return of the observers from Europe and St. Pierre, for the purpose of determining their personal equations and some instrumental constants. The instruments were alike in construction, having forty-five inches focal length, twenty-five inches transit axis, mounted on a heavy cast iron stand and provided with a reversing apparatus. They differed, however, in the arrangement of the diaphragm lines, Mr. Goodfellow having preferred the usual spider lines, Mr. Blake a system of double lines ruled on glass, and Mr. Smith single lines ruled on glass. The personal equations were compared by each observer determining the time with his own instrument in the customary manner, using the same stars, as well as by observing at the same instrument the transit of the same stars over alternate tallies of lines. The results by the two methods were found not to differ sensibly.

The personal equations found are

Blake places himself East of Smith . .	0ˢ·07
" " " West of Goodfellow .	0ˢ·04
Goodfellow places himself East of Smith .	0ˢ·11

The first datum only enters into the longitude Cambridge—Brest, since Goodfellow occupied an intermediate position.

Advantage was taken of the opportunity of placing the three transit instruments in the same meridian, for the purpose of testing them as to flexure of the transit axis, by comparing in each the line of collimation as indicated by reversals, right and left, with that resulting from revolving it about the axis, using the two other instruments as collimators, each being in turn placed in the middle. The collimation resulting from the observation of circumpolar stars in the direct and reversed positions was likewise compared with that from reversal in the horizontal direction of the telescope, using the adjoining one as a mark. The results fully confirmed that there are no sensible inequalities of flexure in these instruments.

At the request of the Superintendent of the U. S. Naval Obser-

vatory in Washington, signals were also exchanged between St. Pierre and Washington during the progress of the work, and subsequently the several observers compared personal equations. Of this portion of the work no results have yet been reported. The second and more elaborate computations of the longitudes St. Pierre—Brest and Cambridge—St. Pierre are also still in progress while this report is going to press, and the final results cannot therefore be given at this time. But they cannot differ materially from those of the preliminary computations, given below, which were made by the observers in the field.

The difference in the time between Brest and St. Pierre, as derived from eastern and western signals, including the personal equations of the operators and the time of transmission forward and back through the cable, was on the average 1·19ˢ, varying five-hundredths from the mean. Deducting from this the sum of the personal equations 0·47ˢ, we find for twice the time of transmission through the cable, 0·72ˢ, or 0·36ˢ for a distance of twenty-two hundred nautical miles. The signal time between St. Pierre and Cambridge was 0·14ˢ.

The following are the results for longitude:

	h.	m.	s.	s.
St. Pierre—Brest, mean of seven nights	3	26	45·20	± 0·05
Cambridge—Brest, mean of eight nights		59	48·78	± 0·03
Correction for personal equation, S.—B.			—0·07	± 0·02
Reduction to Harvard Observatory dome			—0·09	
Harvard—Brest	4	26	33·82	± 0.06
Brest—Greenwich (as above)		17	57·14	± 0·03
Harvard—Greenwich	4	44	30·96	± 0·07

The term Harvard is here used to denote the centre of dome of the Harvard College Observatory at Cambridge, U. S.

Comparing now this result with those formerly obtained, we have for the operations of 1870:

	h.	m.	s.	s.
Cambridge transit—Duxbury	0	1	50·23	± 0·02
Reduction transit to dome			—0·04	
Duxbury—Brest, station of 1870	4	24	42·87	± 0·05
Reduction station 1870 to 1872			+0·79	
Brest, 1872—Greenwich	0	17	57·14	± 0·03
Harvard—Greenwich	4	44	30·99	± 0·06

The figures for Cambridge—Duxbury and Duxbury—Brest are taken from No. xvi, Memoirs of the American Academy, Cambridge, 1873, by Prof. J. Lovering, who had charge of the computations. By reference to that publication it will seem that in those operations the ends of the two cables were joined at St. Pierre, by bringing their several condensers into contact, and in this way the signals were exchanged directly between Brest and Duxbury. The method of transmission was thus quite different in the two campaigns, and the close agreement of results can only be held as dissipating all doubt as to the sensible equality of the rate of transmission in opposite directions.

We will finally compare the preceding results with those obtained in 1866 through the Ireland-Newfoundland cables by the operations conducted by Dr. B. A. Gould, a full account of which is published in the Coast Survey Report for 1867, and also in volume xvi of the Smithsonian Contributions. The results there given lack one link in order to be complete, that being the personal equation between Mosman, the observer at Foilhommerum, and the standard observer at Greenwich. This defect we have endeavored to supply, as far as is practicable after the lapse of some years, through the personal equations between Mosman, Blake and the Greenwich observers in the following manner. The well ascertained equation between Blake and Mosman is that Blake places himself 0·09ˢ to the west of Mosman. He is, moreover, 0·07ˢ to the east of the present Greenwich standard observer (Criswick), who again is ·11ˢ to the east of the standard observer of 1867 (Dunkin). Hence we deduce that Mosman placed himself 0·05ˢ more east than Dunkin, and the former difference of longitude between Greenwich and Foilhommerum must be increased by that amount.

The figures given in the publications above referred to require some other corrections in consequence of the personal equations having been applied with the wrong sign. We therefore recite the several links of the combination as follows:

	h.	m.	s.
1866. Greenwich to Foilhommerum	0	41	33·34
1866. Foilhommerum to Hearts Content	2	51	56·32
1866. Hearts Content to Calais	0	55	37·97
1857. Calais to Bangor	0	6	00·31
1851. Bangor to Harvard Observatory	0	9	23·06
Greenwich to Harvard Observatory	4	44	31·00

Considering the number of separate determinations entering

into this result, we cannot well ascribe to it a probable error less than $\pm$ 0·10ˢ, even when dismissing all further question of the inequality of transmission time in opposite directions. The close agreement of the three independent determinations made in different years is therefore no less surprising than it is satisfactory. We have:

LONGITUDE OF HARVARD OBSERVATORY FROM GREENWICH.

	h.	m.	s.	s.
1866	4	44	31·00	$\pm$ 0·10
1870			30·99	$\pm$ 0·06
1872			30·96	$\pm$ 0·07
Mean	4	44	30·98	$\pm$ 0·05

To deduce finally the longitude of the dome of the U. S. Naval Observatory in Washington City we add 23^m 41·11ˢ, the value deduced from the elaborate determinations in 1867, published in the Coast Survey for 1870 (Appendix, No. 13), and find

Washington—Greenwich . . . 5^h 08^m 12·09ˢ,

and further, using the value Greenwich—Paris = 9^m 21·06 above obtained, we have

Washington—Paris . . . . . 5^h 17^m 33·15ˢ.

APPARATUS FOR ILLUSTRATING THE VARIATION OF WAVE LENGTHS BY THE MOTION OF ITS ORIGIN. By E. S. MORSE, of Salem, Mass.

ABSTRACT.

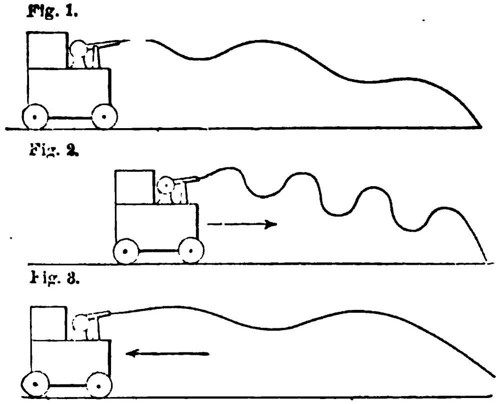
THE interesting discoveries of Huggins and others, in determining the direction of movements of bodies in remote star depths, from displacement of lines in the spectrum, were first alluded to. It is well known that when a star is approaching the observer the luminiferous waves emitted by it are crowded together, and on the contrary are separated when the star is receding. To illustrate this change in the wave lengths, so that it may be

fairly comprehended by students and the public at large, various comparisons have been made, among the best of which is that of Proctor, often quoted by Tyndall, which embraced the conception of a person dropping periodically a series of corks into a stream. If the person dropping the corks stands in one place, they will be, for instance, three feet apart; if he moves with the stream at a given rate, they will be say two feet apart; if he moves up the stream, dropping them at the same rate, they will be four feet apart. Another comparison is taken from the sound of the whistle of an approaching locomotive, which increases in sharpness because the vibrations are more rapid; or, receding, diminishes in pitch. But the latter comparison fails in correctness, because the waves of light and sound are, strictly speaking, incomparable—those of sound moving in pulsations, those of the luminiferous ether in undulations.

Fig. 1.

Fig. 2.

Fig. 3.



MACHINE TO SHOW VARIATION OF WAVE LENGTHS.

Fig. 1. Appearance of waves when the source from which they start is at rest.

Fig. 2. Shortened waves, when the machine producing them moves in the direction of their motion; *e. g.*, in the case of a star approaching the observer.

Fig. 3. Lengthened waves, when their source is moving in a contrary direction.

A plan of an instrument was given by which this phenomenon in the case of light may be easily and plainly illustrated before a large audience. The instrument consists of a tank filled with water and set on wheels. On top of this is a compartment containing compressed air. From one end of the tank a pipe protrudes, which is moved up and down at a fixed rate by

simple clockwork. When the cock is opened, allowing the water to escape from the pipe, the stream assumes a sinuous line, which may be shown, if brilliantly lighted, across a large audience hall. This undulatory stream, when the tank is at rest, illustrates a luminiferous wave from a stationary source. To exhibit the shortening or lengthening of the waves of light by the approach or recession of the luminiferous body, it is only necessary to move the apparatus rapidly back and forth on the table. As the apparatus moves with the direction of the stream its undulations are crowded together, and the waves are consequently shortened. On the other hand, when the motion of the apparatus is in an opposite direction, the waves are proportionably lengthened. The advantage of this illustration is that it exhibits precisely what takes place in the luminiferous waves approaching or receding from the observer of celestial bodies, producing the displacement of spectrum lines.

THE SOLAR PHOTOSPHERE. By S. P. LANGLEY, of Allegheny, Pennsylvania.

HAVING been engaged, more or less, for the past three years on the study of the Solar Photosphere, I desire to give, on the part of the Allegheny Observatory, some brief account of the nature of this portion of its work in advance of a more complete publication. The labors of Schwabe, Carrington and others abroad, and of Peters in this country, have been directed to the determination of the laws of the motions of spots upon the solar surface from drawings and measurements, and these (supplemented by photography since for the same purpose, at Kew and elsewhere) have left little for others to add in that branch of the subject. The field of solar research, however, is unlimited, and the interesting questions, raised by the discussion of recent theories as to the nature of cyclonic action, led me to commence a series of drawings in which the attempt was made accurately to delineate upon the largest practicable scale some one spot or

group, from the time of its first appearance at the eastern limb, daily, until it passed from view, for the specific purpose of determining the extent of any gyratory movement of the spot upon its own axis, or any motions of its parts among themselves, and not with the aim of ascertaining the laws of its movement of translation. While the heliocentric coördinates were therefore determined only with a precision sufficient to indicate the spot's approximate place, the drawing itself was rather a map than a picture, being intended to embody the results of micrometrical measurements throughout. I have in accumulating many data of this kind, which are still awaiting reduction, been led incidentally to a study of the minuter details of the surface, and to an impression that the interest of recent spectroscopic discoveries has rather unduly diverted attention from what remains to be done by the older methods. Although considerable labor has been devoted at Allegheny to the class of observations to which I refer, as well as to a revision of the early researches of Henry with the thermopile, and the subsequent ones of Secchi, I wish here to give only some brief account of researches carried on with the telescope alone, and which seem to me to offer some suggestions which may be of interest in reference to physical theories of the solar circulation, since they are obtained by a method independent of the spectroscopic researches upon which these theories have of late been chiefly based.

I may presume that every student of the subject is acquainted with the controversy which arose some ten years since out of Mr. Nasmyth's supposed discovery that the solar photosphere was composed of bodies shaped like willow leaves, very definite in outline and about 0·4″ in width by 2·00″ in length. Since that discussion, which left our knowledge of the minute structure of the photosphere still in an unsatisfactory state, very little indeed has been done in this direction, and what observations have since been added have been often so apparently contradictory, that I think it would be difficult to point to an account of any considerable detail which has not been controverted or left in doubt by some other observer.

The cause of this lies chiefly in the extreme difficulty of such observation, yet not wholly. The nomenclature of the subject is in a regrettable confusion, scarcely any two observers using their descriptive terms in the same sense. To fix my own meaning

let me premise that by the "nuclei" of a spot, I refer to certain dark shades discernible by special caution within the umbra, in some cases, and that while not using the word with the exact significance that Mr. Dawes seems to have attached to it, I agree with him in employing it in this restricted sense, where others have made it a synonyme for the umbræ themselves. By "pores" I mean relatively dark portions of the photosphere, where the withdrawal of the aggregations of luminous matter for a little space exposes a relatively gray medium, in which these incandescent aggregations appear elsewhere to float. The word "rice-grains" I use provisionally in the sense apparently attached to it by Mr. Stone. As it will appear from all I have said that there is a peculiar liability to misconception here, I aid the explanation of my meaning as I go on, by these colored drawings,* and will first briefly describe the appearance of the photosphere in telescopes of moderate power and in good photographs, in order to prevent any confusion of what is thus seen, with that of the minute structure hereafter described as visible in the most powerful telescopes only under favorable circumstances.

When with a telescope of moderate power, we project the image of the sun upon a white surface, we see a disc of nearly uniform brightness, but which is yet perceptibly grayer at the circumference than near the centre. Elongated and very irregular patches of white are seen near the edges (very commonly surrounding a spot there), in relief against this gray, and these (which are the well known *faculæ*) and the spots themselves are all that at first sight appear to break the uniformity of the disc. Let us discard them from mind and confine our attention to the nearly uniform white surface of the central part of the sun. With proper care, and while still using a moderate aperture, this surface is seen to be mottled with small cloud-like forms, which are of no definable shape, and which elude any attempt to delineate their outline. They may be observed in some superior photographs of the sun, notably in those obtained by Mr. Rutherford, and in those taken at Cambridge by the reflecting mirror and long horizontal telescope as used by Professor Winlock. They are only well seen, however, in a comparatively small number of photographs, and appear to be missed when the atmosphere is not in a very favorable state. Still they are visible, as I say, in the projected

* Three drawings in color were exhibited at the time the paper was read.

image obtained from a telescope of moderate power. Their general appearance may be not inaptly compared to that of flocks of wool strewn on a white cloth, from which their color is just distinguishable, and I mention this fleecy structure, seen in ordinary telescopes and good photographs, only to request that it may in no way be confounded with its far more minute components I am about to describe.

We shall shortly have occasion to look in the white photospheric surface for bodies which are nearly its own color, and whose probable diameter is less than $0{\cdot}\frac{1}{2}''$ of an arc, and as these lie close together, it is evident that however bright the light, we cannot avoid the indefiniteness caused by diffraction without the use of apertures, at least as large as those requisite for the closest double stars. We must of course then use for this research, telescopes such as are seldom found in private hands, and this, with the intrinsic interest of the study, points it out as a fit subject for the employment of the large equatorials of our regular observatories. That of the Allegheny Observatory, employed in the present case, has thirteen inches of aperture.

When we use a large telescope upon the sun, we find two great difficulties; one the excessive light and heat, the other the disturbance produced in our own atmosphere, and which is greater by day than by night. For the first difficulty we employ special optical aids such as the Dawes eye-piece or, far better, the polarizing eye-piece, which gives an image of the sun sensibly devoid of color, and of any brightness desired. For the second there is no remedy but assiduity and patience.

In this kind of investigation, drawings are very necessary, but rather such as emulate the fidelity of the topographical draughtsman, than such as aim primarily at pictorial effect. I am accustomed to try to secure accuracy in the numerous details which the photograph cannot yet reach, by reducing everything to micrometrical measurement, where it is possible. A very useful help, where we have a large equatorial provided with clock-work, is to attach to the instrument a light frame, which holds a sheet of paper at any convenient distance from the eye-piece, and perpendicular to the optical axis. The Position Filar Micrometer being in its place, when the instrument is turned on the sun, an enlarged image of the spot is projected upon the paper, and the wires of the micrometer along with it. Then the projection of the

spot may be made to run along the projection of the wire, just as a star is made to run along the wire itself, and measurements may be made both of position and magnitude, as accurately as in any ordinary use of the instrument, and with a rapidity otherwise unattainable;—a rapidity indispensable in an object which so incessantly changes its form. In practice it is usually even yet better to draw an accurate scale upon the paper itself, to ascertain its value in arc by the transit of the solar limb over it, and then to trace the outlines of the spot directly on the paper, on which it remains fixed while the sheet is carried along by the clock-work. This projection it will be understood is merely a skeleton to be enlarged and filled in by subsequent direct study with the polarizing eye-piece, to which the ordinary micrometer is not well adapted. For the still enhanced accuracy of work with this (the polarizing eye-piece), Professor Rogers, now of the Harvard College Observatory, has had the goodness to rule for me two of his very beautiful glass reticules, which may also be employed in the focus with a full aperture where the common web would be burned. I have not yet, however, had an opportunity of using these reticules to their full advantage, and have temporarily employed coarser graduations on mica, as a special micrometer for use with the polarizing eye-piece. With an instrument I designed some years since, and in which the ray is polarized with three successive reflections, the eye may be placed in the actual solar focus of the lens of thirteen inches aperture without the intervention of any colored medium and without inconvenience.

When with such improved optical and other aids, we now return to the study of the photosphere, we are enabled to see that the fleecy or cloud-like surface, first mentioned, is a singularly complex structure. Isolate, as far as we can, any one of these scarcely distinguishable fleeces on the solar surface, *its* surface in turn is found to be covered with small patches of gray, united by whiter lines of most irregular form, and which it is hard to distinguish clearly from the background, which they so much resemble in color. The size of these gray patches, which have received the name of Pores, is very various, and they appear to be caused by the absence of the clusters of whiter nodules, which as it will be seen, make up the photosphere. The great variety in their sizes and shapes makes any direct estimate of their magnitude unreliable, but we may say in a roughly approximative way, that the

average linear diameter of the more conspicuous pores is from 2″ to 3″ of arc. The photospheric surface is filled with small, intensely bright, masses, chiefly oval or elongated, half defined by a faint gray background from which they are just distinguishable, which blend into each other, and in looking at which the eye is tantalized by the fitful appearance of a still more minute subdivision, which is rather suspected than seen. The fleecy appearance seen in good photographs, and which has been before described, is due then to the aggregation of these forms, which I understand to be designated by the term "Rice-grains." Finally, in moments of the very rarest definition, with large apertures and very considerable magnifying powers, these "Rice-grains" or "Granules" I have in turn resolved into unequally brilliant minute nodules, circular or very slightly elongated, each usually separate and distinct (as although numbers of them may be in juxtaposition their lines of demarcation are yet visible), and whose average diameter is probably much within one-half of a second of arc. The ultimate structure then, of the photosphere, is found to consist of these seemingly discrete bodies, which float, as it were, in an ocean of comparatively gray fluid. These bodies are visibly the principal source of the solar light, their remarkable individuality being perhaps on the whole their most notable feature. The aggregation of these excessively minute nodules forms the "Rice-grains;" themselves seen in large telescopes only under more than ordinarily favorable circumstances; and the aggregation of "Rice-grains" and "Pores" combines with confused definition to present the fleecy appearance which is generally easily recognized, and which bears some resemblance to our clouds, while for the primary components I know of no analogy in our terrestrial atmosphere. Considering that Mr. Nasmyth's "willow-leaves" are something like two entire seconds of arc in length, and that the photosphere has been resolved by Secchi, and perhaps by others beside the writer, into discrete bodies of less than one-fourth this size, it is allowable to say with confidence, that if such willow-leaved shapes always exist, they would have been seen. Still I think from Mr. Nasmyth's drawings, that he was the first or among the first to get an idea (though a partially incorrect one) of the ultimate structure of the photosphere; and those only who know, from their own experience, that sometimes three months of daily observation will not in our climate yield in the aggregate fifteen minutes of

such study seeing that these "Rice-grains" even can be clearly distinguished from each other, with the best optical means, will understand how easy it is for conscientious and able observers to differ among themselves as widely as Nasmyth, Dawes, Secchi and others did at first, in their accounts of this singularly interesting, but singularly difficult, observation. Let us now study these bodies in the vicinity of a sunspot, and in the spot itself, of which they constitute under a modified form the most important feature. Let us view them in some small isolated spot before we examine them in larger and more complex ones.

As we approach the spot, we see them elongated and protruding upon the gray boundary of the penumbra. This penumbral edge is always, I think, far more irregular than ordinarily drawn, and its irregularities are resolved in the best seeing into these minute ultimate constituents of the solar surface. The outer border of the penumbra, it is readily observed, is darker than its interior edge; but it is a fact of interest I have not seen remarked upon, that this outer penumbral shade is nothing else than the gray interstitial matter, which covers the whole solar surface, and in which the "Rice-grains" appear elsewhere as suspended. The impression is vividly conveyed in good seeing that these "Rice-grains" are really filaments of considerable length, whose extremities only are seen on the surface (a fact first discovered I think, by Mr. Dawes), and that there is a break in their continuity around the spot. They are dimly seen occasionally through this gray penumbral edge, and reappear as the well-known "thatch-straws" of Dawes, over all the inner part of the penumbra, and especially where they are seen projected on the darker umbral shade. It will be understood that I find both rice-grains and thatch-straws are in turn resolvable, and that I consider the "Rice-grain" and "Thatch-straw," one and the same thing under different aspects, and that both consist of a union of more minute filaments. I will, however, continue to use the term (filament) here, in the sense in which it is employed by others, though it should perhaps be reserved to indicate this minutest and scarcely recognized subdivision.

We can derive most essential aid, in the study of currents within the spots, from these filaments, the spectroscope telling us partly of the direction of the motion, but nothing definite as to the location and inclination of the currents whose interaction is so well

worth study. Their disposition enables us to see, I think, that the theory of the sun-spot so ably developed by Faye, and which is so fertile in explanation of the most diverse phenomena, is yet to be extended or modified in some details. There appears for instance to be a less marked cyclonic action in the small and unsegmented spots. So far as my observation has gone, these filaments are not, in such cases, to be ordinarily seen bent by any single whirlwind so that they have a common spiral tendency. Not unfrequently the filaments, or rather the thatch-straws, are short, nearly straight, and lying in quite different directions like a heap of jackstraws. It is, it is true, the rule and not the exception to find them curved, but it is ordinarily by what seems to be the action of small and independent local whirlwinds. A gyratory movement of the spot as a whole, about a motionless axis, may exist, but it is not plainly marked on the filaments, which are such sensitive indices of other local action. Nearly associated with these small local whirlwinds are the evidences apparently of both an upward and a downward current, in the umbra of the same spot, and sometimes of several such. The polarizing eye-piece shows that the nuclei or darker shades of the umbra occupy no certain position near the centre, such as Mr. Dawes was disposed to assign them, and that the umbra itself is a very complex structure, crossed not only by the well known bridges or bright ropes of filaments which invade and lie along it, like tangled white threads upon an ink spot, but that it (the umbra) is made up largely of these same filaments, which are dimly seen, as it were, beneath its surface, and often of a reddish brown on the violet purple of the umbra, which is also sometimes studded with minute points of light, formed apparently by the tips of the filaments which are occasionally presented to us here in the same foreshortened position, as on the general surface. In Secchi's work umbral colors are occasionally depicted of as vivid a crimson as that of incandescent hydrogen seen on a bright background. This intensely vivid crimson I have not observed, though a brick-red tint is not uncommon. If the downward current were at the centre of the spot, and the compensating uprush at the edge of the umbra, we might expect to find the ends of the filaments which overhang the umbra, brighter than elsewhere, and this is ordinarily the case, but it is a rule not without exceptions. I have seen these bright threads of light, bending down and growing darker as though further and further immersed in some dark

fluid; like rushes overhanging a turbid stream, in which their points are dipped and in which the eye can follow them below the surface. I have seen again these thatch-straws presenting an appearance analogous to that to which geologists give the name of a "fault;" as if broken with a continuous line of fracture running transversely to their length, over nearly one-third the circumference of a spot, and the lower portion partly overflowed, if I may use the term, by the umbral shade.

It appears, then, that even in small spots there are sometimes several centres of action, and this view is somewhat strengthened by the fact that a cyclonic action extending uniformly over the whole spot is so rare. The filaments, though very generally bent, are bent in different directions, and as though by many small and independent whirlwinds, moving in concert as we may see them in a dusty street. I have also frequently observed in these filaments evidence of superposed currents, nearly as definite as that we obtain when we look up to our sky to see one set of clouds moving over and in an opposite direction to another.

I cannot convey without drawings made with more graphic skill than I possess, an adequate idea of the extraordinary forms these filaments assume, but I would insist on the fact that they under almost all circumstances, preserve the appearance of individual bodies. Whether seen on the general photosphere, or in the penumbra, or projected on the umbra, they rarely or never seem to merge into one another; however they may be massed together and twisted by the solar whirlwinds, they remain distinct like the strands of a rope. Even in the bridges of light over the umbra, which appear at first to be composed of a fusion of them, a fine, scarcely visible dark line may be traced in good seeing, along the bridge, which testifies to the unsurrendered individuality of the component parts. It is very difficult to conceive of matter in any form that we know it, which would behave just as this does. They (the filaments) are seen at times bending into graceful flame-like curves as though perfectly pliable; at other times they may be found (apparently) broken abruptly. They are collected at times in the large spots into forms of the most tantalizing complexity, strangely suggesting something that is both foliate and crystalline in structure, and I have seen such which could be compared to the most complex and beautiful forms ever traced by the frost on a window pane. In some large spots, the centres of

violent disturbances, I have seen in those very rare moments when the highest power of a great telescope may be used, forms of which I should almost hesitate to present an uncorroborated delineation, were I able, so unlike are they to those commonly depicted in sun-spot drawings, and so curiously do these exceptional forms simulate those of vegetation. Even the generally excellent drawings of Secchi completely fail here, as indeed anything but the photograph must fail, and our subject is unhappily far beyond the reach of anything solar photography has done yet.

As to the size of these rice-grains or filaments, it will be remembered that estimates of the most varied kind have been made by skilled observers. Chacornac, in a communication to the "Comptes Rendus" of the Institute, states that he finds the average diameter of the rice-grains to be one hundred and sixty leagues, which is almost precisely 1″ of arc. Nasmyth makes their length something like twice as great, and Secchi gives a value very much less than either. I have made one set of measurements with the mica scale, the value of whose division was approximately 15″, by counting the number of umbral threads to each division. The mean of three such measurements gave 1·14″ as the distance of the observed threads from centre to centre. The measurements were made with the polarizing eye-piece, but were varied on one occasion when the atmosphere was so exceptionally tranquil, that the solar image could be projected upon a graduated screen with such definition that the individual filaments were counted on the paper, and their number to a division estimated. This quite independent determination gave 1.08″; these measurements including, with the filaments, the considerable space which separates each from each.* I have never as yet been able to obtain sufficiently precise vision for micrometrical work upon these bodies on the general photosphere. There is an admitted assumption therefore, in taking this measurement to be the same which might have been found at the other extremity of the filaments where they appear

* Subsequent measurements, under very favorable circumstances, gave where taken on a group of filaments lying in unusually close juxtaposition, a mean of rather less than six-tenths of a second for the sum of the width of the filament and that of the space separating it from its neighbor. In the case of both rice-grains and filaments irradiation masks the true figure, while enhancing the apparent size; of this intervening space of 0·6″, then, the share that is to be assigned to the filaments must be partly conjectural. If we assume the filaments as equal in absolute diameter to the interval which separates them (which I can hardly think they are), we obtain 0·3″ as the approximate size. Note added March, 1874.

at the surface; I feel confident, however, from repeated scrutiny, that the difference, if it exist, is inconsiderable. I believe we have no data yet from any source which will enable us to speak positively as to the absolute size of the filaments, as we cannot yet allow for the effect of irradiation; still if we assume the width of these bodies to equal only the average space between them, we shall find it not more than half of a second of arc, at the most; but it may for anything we can yet tell, be much less. All that we can now do is to assign an upper limit to their diameter, and this I think cannot, ordinarily exceed one-half of a second of arc. It is well to repeat that it *may* be almost anything less, irradiation here masking the real magnitude as it does in the case of a star. It is very desirable that more measurements be obtained, and it is not through negligence that I have failed to multiply them as I should have been glad to do, till their probable error could be determined, but it will be remembered that a year may pass by without bringing more than a few hours of consecutive seeing, good enough for this very difficult work, in which only large apertures and high powers can be used, for we can employ high powers probably ten times at night on a star, where we can once with advantage upon the sun, owing to the greater atmospheric tremor by day and the distortion of the image by the unequal heating of the anterior and posterior surfaces of the object-glass.*

In this connection, I will, while repeating that the whole of the umbra appears to be frequently composed of forms not unlike the penumbral ones, add that the color as well as the light of the isolated umbra is usually decided. I have, with some care, made an experiment which is very simple in conception, and which, though not easy in practice, I am surprised to find no record of elsewhere. It consists in completely cutting off all extraneous light emitted by the penumbra and umbra, so that none can be received by the eye, unless it be from the apparently perfectly *black* "nucleus" or core of the umbra. The eye being so placed that it can receive light from that alone, this intensely "black"

*Since reading this paper, I have had several opportunities for extending these measurements. The detailed results of later researches would not be in place here, but I may say that I should now rather reduce than enlarge the estimates of the size of the filaments here given, and that it seems probable that with the opportunity of applying higher powers, the resolution of these filaments or of the components of the rice-grains, into still minuter aggregations, is likely to go on indefinitely. Note added March, 1874.

nucleus is seen to shine with a dazzling light, ordinarily of a violet tint. I have also received the umbral light upon a screen so arranged as to be illuminated only by it, and by diffused daylight, and then with brush and color made a large number of imitations of its tint directly upon the paper beside it, until one was found, which, in the independent jndgment of two persons, most nearly represented it. It was nearly matched by the purple technically called "violet-carmine" (*colored sheet exhibited*).

One objection against the gaseous theory of the sun, urged, I believe, by Mr. Herbert Spencer, as well as by professional astronomers, has been that the laws of gaseous radiation oblige us to believe that the body of the sun (if purely gaseous and dark) would be transparent; that we should hence be enabled to see the photosphere upon the other side quite through the whole body, (thus looking through the sunspot as through a window to light beyond), and that a necessary result of a purely gaseous sun with a non-luminous interior would hence be that sun-spots would not be visible at all. This reasoning, in itself theoretically justifiable, evidently here rests on an assumption as to the *fact* of the blackness of the nucleus, an assumption which must have appeared, at the time it was made, quite justifiable, it being founded probably on the language of Mr. Dawes; an excellent and usually most cautious observer, but who in this case in speaking of the "perfectly black" nucleus used too unqualified terms.

To restate in a few words the substance of what has been said: —

The surface of the whole sun is covered with filiform bodies which are of an average diameter of not greater than one-half of a second of arc, and whose length is undetermined, but very considerable. The aggregation of these upon the surface has given rise to forms which, seen under ordinary definition, might possibly be mistaken for a "willow-leaf"-like structure, but no such spindle-shaped or willow-leaved bodies (in the sense in which Mr. Nasymth first described them) exist. The study of these bodies where seen in the penumbra, though difficult, forms at present, perhaps, our best means of learning the direction of solar currents, the most prominent results being that the dominant type is that of forms evidently due to cyclonic action, and that cloud strata superposed in a complex manner, and drifting over one another in different directions are also common. While the existence of

some such appearances as the minute photospheric forms present when aggregated upon the surface, and when segregated and drawn out in the penumbræ, may be recognized under the respective terms of "rice-grains" and "thatch-straws," such phrases, unqualified, are calculated to mislead, and should be replaced by more accurate ones representing the results of a critical study of bodies, which whatever be their nature, are the immediate sources of the solar light, and which are in every way deserving of far more attention than they have received.

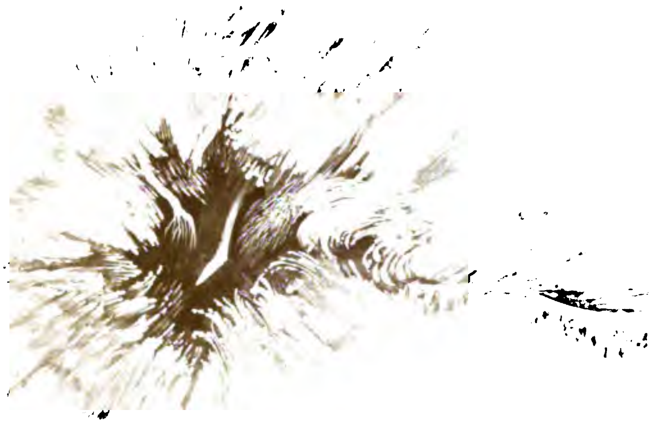
The best photographs are as yet far from being able to represent these forms, and careful drawings based directly upon micrometrical measurements, and in which pictorial effect is considered only as it is incidental to minute fidelity, afford at present our best means of studying them, and (by comparison) of correcting the effects of subjective peculiarities of the observer.

The great utility of a very elevated station for observation, which has been brought into renewed notice by recent spectroscopic acquisitions, would seem however to promise every gain for such researches as these.

What has just been said will not be understood to be meant to depreciate the great advantages which photography can render now, in researches as to the motion of the spots, and it may be hoped is destined to render, as to the minute details of their structure. No one can be more conscious than I am, of the inevitable defects of such drawings of the minute structure as this, or more desirous to see photography take their place, which, however, the time has not yet come for it to do. Aware of the little I have been able to attain certitude on, I deem it best to confine myself at present to a simple description of what appear to be facts of observation, without on this occasion offering any hypothesis as to the nature or function of the things described.

REFERENCE TO PLATE.

I have been enabled by the kindness of the Association to add to this paper a photographic reduction of one of the drawings exhibited at the Portland Meeting, which I have slightly modified since, that it might embody results more recently attained. It might be called a typical sun-spot, as it is rather a collection of typical forms taken directly from studies made and compared at the telescope, and then brought together in their proper physical connection, than an attempt to delineate exactly any particular spot at a given moment. This method of procedure is in fact unavoidable, as spots change so rapidly that drawings of any accuracy of detail must present features which would not have been simultaneously seen. No attempt is made to give any specific photospheric forms away from the spot or anything else than the general appearance of the photosphere. In the spot, however, everything is (as far as my ability to represent what I saw goes) a minutely literal transcript of so much of what presented itself in good definition at various times as was unquestionably seen.



Allegheny Observatory

S P Langley del.

TITLES OF COMMUNICATIONS.

The following titles of papers read in Section A include those accepted by the committee for publication in full, but of which the authors have failed to send copy, as well as those which the committee decided should be printed by title only:

On a New Form of Break-circuit and the Electric Control of Chronographs. By C. A. Young, of Hanover, N. H.

The Solar Envelope. By C. A. Young, of Hanover, N. H.

Meridional Arcs measured in the Progress of the Coast Survey. By J. E. Hilgard, of Washington, D. C.

On Solar Disturbances of the Magnetic Needle. By J. E. Hilgard, of Washington, D. C.

On Methods of Determining the Ratio of Volume and Weight of Water. By J. E. Hilgard, of Washington, D. C.

The Coefficient of Safety in Navigation. By William A. Rogers, of Cambridge, Mass.

Notice of some Experiments in Etching on Glass. By Wm. A. Rogers, of Cambridge, Mass.

On the Periodic Error of the Right Ascensions of the Nautical Almanac, and its Effect on the Longitudes which depend on them. By Wm. A. Rogers, of Cambridge, Mass.

Notice of a Machine for Ruling Microscopical Lines. By Wm. A. Rogers, of Cambridge, Mass.

On the Substitution of Double for Single Threads in Transit Instruments, and of Diagonal Threads for Micrometers in Zenith Telescopes. By Wm. A. Rogers, of Cambridge, Mass.

The Atmospheric Electricity of the Earth, of the Sun and of the Comets; and the Physical Constitution of the Sun and of the Comets. By Jacob Ennis, of Philadelphia, Penn.

The Telescope and the Means of Improving it, and also the Utilization of Solar Heat. By George W. Holley of Niagara Falls, N. Y.

Note on the Rotation of the Planets as a Result of the Nebular Theory. By Benjamin Peirce, of Cambridge, Mass.

Facts and Suggestions in Proof of the Theory of the Gradual and Continual Diminution of the Quantity of Water upon the Earth, and its Conversion into Solid Forms of Matter. By Mrs. George W. Houk, of Dayton, Ohio.

Cold Water Condensers. By Joseph B. Walker, of Louisville, Ky.

On the Inconceivable Elasticity of the Hetéric or Common English Alphabet. By Wm. Boyd and H. G. Allen, of Cambridge, Mass.

Methods for Regulating the Motion of Chronograph. By G. W. Hough, of Albany, N. Y.

Relation of Frequency of Auroras to Changes in the Length of the Earth's Radius Vector. By E. B. Elliott, of Washington, D. C.

The Cohesion of Liquids. By George J. Wardwell, of Rutland, Vt.

Investigation into the True Cause of a Peculiar Form of Mirage. By P. H. Van der Weyde, of New York, N. Y.

Periodicity of Rates of Interest in the New York Market. By E. B. Elliott, of Washington, D. C.

Irregularities in the Returns of the Population of the U. S. Census of 1870, at Earlier Ages, with Methods and Results of Correction and Adjustment. By E. B. Elliott, of Washington, D. C.

Life Table, Table of Mean Future Duration of Life, and Table of Life Annuity, on the Basis of the U. S. Census of 1870, with Method of Construction. By E. B. Elliott, of Washington, D. C.

International Coinage—its Progress. By E. B. Elliott, of Washington, D. C.

METHOD OF HARMONIZING APOTHECARIES' AND THE METRIC SYSTEM OF WEIGHTS. By E. B. ELLIOTT, of Washington, D. C.

METRIC AND RADIAL SYSTEMS OF MEASURES OF LENGTH. By E. B. ELLIOTT, of Washington, D. C.

ON THE CREDIT OF THE U. S. GOVERNMENT, AS INDICATED BY THE DAILY MARKET QUOTATIONS OF PRICES OF ITS SECURITIES. By E. B. ELLIOTT, of Washington, D. C.

ON THE DISSOCIATION OF WATER BY HEAT AS A CAUSE OF STEAM BOILER EXPLOSIONS. By L. BRADLEY, of Jersey City, N. J.

AN AUTOMATIC FILTERING APPARATUS AT WORK, DESCRIBED IN MAY NUMBER OF AMERICAN JOURNAL OF SCIENCE. By H. W. WILEY, of Indianapolis, Ind.

THE UNRELIABILITY OF LIFE STATISTICS AS USUALLY COMPILED. By T. S. LAMBERT, of New York, N. Y.

EXHIBITION OF A MICROSCOPE OF NOVEL CONSTRUCTION, WITH NEW STYLE OF MICROMETER AND REMARKS ON THE METHOD OF ENLARGING THE FIELD. By P. H. VAN DER WEYDE, of New York, N. Y.

REMARKS ON A PROJECTED GIGANTIC TELESCOPE. By P. H. VAN DER WEYDE, of New York, N. Y.

REMARKS ON THE ANGULAR APERTURE OF IMMERSION OBJECTIVES FOR THE MICROSCOPE. By R. H. WARD, of Troy, N. Y.

ON HEATING IRON BY HAMMERING. By F. W. CLARKE, of Washington, D. C.

SOME REMARKS ON THE EQUILIBRIUM AND DYNAMIC THEORIES OF THE TIDES. By J. G. BARNARD, of New York, N. Y.

REMARKS UPON THE LAST CIRCULAR OF DR. PETERMANN, FROM THE SWEDISH AND NORWEGIAN ARCTIC EXPLORING EXPEDITIONS. By WILLIAM W. WHEILDON, of Concord, Mass.

PART II.

SECTION B,

NATURAL HISTORY.

B. NATURAL HISTORY.

On the Duty of Governments in the Preservation of Forests. By Franklin B. Hough, of Lowville, N. Y.

The presence of stately ruins in solitary deserts, is conclusive proof that great climatic changes have taken place within the period of human history in many eastern countries, once highly cultivated and densely peopled, but now arid wastes.

Although the records of geology teach that great vicissitudes of climate, from the torrid and humid conditions of the coal period, to those of extreme cold which produced the glaciers of the drift, may have in turn occurred in the same region, we have no reason to believe that any material changes have been brought about, by astronomical or other natural causes, within the historic period. We cannot account for the changes that have occurred since these sunburnt and sterile plains, where these traces of man's first civilization are found, were clothed with a luxuriant vegetation, except by ascribing them to the improvident acts of man, in destroying the trees and plants which once clothed the surface, and sheltered it from the sun and the winds. As this shelter was removed the desert approached, gaining new power as its area increased, until it crept over vast regions once populous and fertile, and left only the ruins of former magnificence.

In more temperate climates the effect is less striking, yet it is sufficiently apparent everywhere and throughout our whole country, but especially in the hilly and once wooded regions of the eastern and northern states. In these portions of our union the failure of springs and wells, the drying up of brooks which once supplied ample hydraulic power through the summer, and the increasing difficulties of procuring water to supply canals for navigation, and wholesome water for cities, are becoming every day something more than a subject of casual remark. It is destined to become a theme of careful scientific and practical inquiry, to ascertain how these growing evils may be checked, and whether the lost

advantages may be regained. We regard the ocean itself as the source whence the moisture, precipitated in rains, is mainly derived. Its area changes not; the exposure to solar heat is uniform (unless, as some suppose, the spots on the sun's disk may have an appreciable influence); and, except as varied within fixed limits by the inclination of the earth's axis in its revolution around the sun, there are no astronomical or other causes that should sensibly change the annual amount of general evaporation from the surface of the ocean from year to year or from age to age. The vapors raised from the sea are distributed by the winds over the land, and descend as rains where mountain ranges, forests and other causes favor condensation. It is probable that the Gulf of Mexico furnishes more vapor for rain within the United States than the Atlantic Ocean, its influence being felt throughout and beyond the great basin of the Mississippi and its tributaries.

In a work which I recently prepared for the Regents of the University of the state of New York, I was able to collect, from all sources and for various periods, in some stations for almost half a century, about two thousand years of rainfall records within the state of New York; and in a volume published within the last year by the Smithsonian Institution, there is a much more extended series for the whole country. These extensive series are not enough to determine, with any claim to accuracy, the secular changes, if any, that may be going on, in the amount of precipitation of rain and snow. Although they reveal great irregularities in a series of years at any given locality, they do not justify us in supposing that, in the general average of periods, the amount is sensibly increasing or diminishing, although they do show, in some cases, greater tendencies to drought for a series of years together, and often a more unequal distribution of rain throughout the year.

This growing tendency to floods and droughts can be directly ascribed to the clearing up of woodlands, by which the rains quickly find their way into the streams, often swelling them into destructive floods, instead of sinking into the earth to reappear as springs. Aside from the direct effects of shelter and shade afforded by trees, the evaporation of raindrops that fall upon the leaves, and the chemical action of the leaves themselves, have a marked influence upon the humidity and temperature of the air beneath and around them. The contrast in a very dry season,

between an open and sunburnt pasture, and one interspersed with clumps of trees, must have been noticed by every careful observer, and the actual relative profits of farms entirely without trees, and those liberally shaded (everything else being equal), will show, at least in grazing districts, the advantage of the latter in the value of their annual products. The fact that furniture, in houses too much shaded, will mould, is a familiar and suggestive instance of the humid influence of trees, and the aggregate results of woodland shade may well explain the fulness of streams and springs in the forest, which dry up and disappear when it is removed.

The economical value of timber, and our absolute dependence upon it for innumerable uses in manufactures and the arts, the rapidly increasing demand for it in railroad construction and the positive necessity for its use in the affairs of common life, even were its use as fuel largely supplanted by the introduction of mineral coal, are too obvious for suggestion. It is this necessity, rather than considerations of climate or of water supply, that has led in several countries of Europe to systems of management and regulation of national forests, as a measure of governmental policy and public economy. Such systems have been devised to a greater or less extent, in Russia, Turkey, Austria, Germany, Italy, France, Denmark and Sweden; and more recently in British India. The extent of state forests in France, is about 3,130,000 acres; to which may be added 5,335,000 acres belonging to communes, corporations, hospitals, and other public establishments, making the whole extent of forest under the management of the forest administration, 8,465,000 acres, or about 13,226 square miles. They are distributed widely over the country, a large proportion being in the departments of the east. Legislation in France having in view the preservation of forests, chiefly dates from the ordinance of 1669, which fixed a certain time for the cutting of forests belonging to the state. A clause was inserted by the statesman Colbert, "that in all the forests of the state, oaks should not be felled unless ripe, that is, unable to prosper another thirty years." The present French Forest Code was established in 1827. It intrusts the care of public forests to the Ministry of Finance, under a Director General, assisted by two administrations; one charged with the management of forests, and the sale of their products, and the other with the police of the forests, and the enforcement of forest laws. In the departments there are

thirty-two Conservators, each in charge of one or more departments, according to the extent of forests in each. The immediate supervision is intrusted to Inspectors, who are assisted by sub-inspectors and *Gardes Généraux*, who live near, and personally superintend the work of the forest guards. The latter live in the forests, and act as police over a certain range. They personally observe the operations, and report all infractions of the laws. No timber is cut till marked, and most of the saw-mills are owned by the government, and rented to the wood-merchants. The system has been extended to Algeria, where several rainy days have been added to July and August, by forest culture.

These details might be extended, but they would not have practical application with us, because our states, as a general rule, own no large forests, and we have no strong central organizations or means of enforcing the stringent regulations which make their system a success. The title to the lands in our older states (where the evils resulting from the loss of forests are liable to be first and most severely felt) has already passed into the hands of individuals, and from the theory of our system of government, the power that must regulate and remedy these evils must begin with the people, and not emanate from a central source. With us, there are no great estates, entailed upon future generations, to keep together, and promising a reasonable hope of reward to the family for a heavy investment in their improvement. Nor is there even a reasonable prospect that the landed estate of a wealthy citizen will pass unimpaired and undivided beyond one generation of his descendants. It should also be remembered that, from the peculiar nature of forest culture, one generation must plant for another to "reap," as the age of a full-grown tree in some species much exceeds that of a human life. The investment for land, planting and protection, must be carried with interest into another century, and for the benefit of a generation unborn.

These considerations present a problem difficult, it may be, of solution, but I have confidence in the ability of our American people to work out a practical system, adapted to our social organization, and our general theory of laws. We must begin at the centre of power, and that centre is the circumference. We must make the people themselves familiar with the facts and the necessities of the case. It must come to be understood that a tree or a forest, planted, is an investment of capital, increasing annually

in value as it grows, like money at interest, and worth at any time what it has cost—including the expense of planting, and the interest which this money would have earned at the given date. The great masses of our rural population and land owners should be inspired with correct ideas as to the importance of planting and preserving trees, and taught the profits that may be derived from planting waste spots with timber, where nothing else would grow to advantage. They should learn the increased value of farms which have the roadsides lined with avenues of trees, and should understand the worth of the shelter which belts of timber afford to fields, and the general increase of wealth and beauty which the country would realize from the united and well-directed efforts of the owners of land in thus enriching and beautifying their estates.

In this great work of popular education, agricultural societies and kindred associations may do much, by promoting a spirit of emulation, and offering premiums for the most effectual results. In a recent premium list of the Highland and Agricultural Society of Scotland, I notice *fourteen* prizes offered, amounting to one hundred sovereigns, in medals and coin, for approved reports upon the subject of tree culture in its various relations. They have also established a system of examinations, by competent professors of their universities, at which young men may appear and receive certificates of attainment, according to degree, which can scarcely fail to find for them profitable employment by the owners of forest estates. They afford a strong incentive to high ambition, and a conspicuous opportunity for those who seek distinction in a lucrative and honorable employment.

The necessities of European governments have led to the establishment of Schools of Forestry for instruction in the sciences that find application in the growth, preservation and removal of timber, in which an eminently practical system of education is adopted, and the precepts of the class-room directly applied in the operations of the forest. About a dozen such schools exist in Belgium, Denmark, France, Germany and Switzerland. The necessity for special education in this department is sure to arise in our own country, in which perhaps fewer persons will find a special profession in forestry, but a greater number will feel the want of practical instruction in the principles upon which success depends.

Our educators would act wisely in taking this into consideration, in devising plans for new institutions, or revising plans of existing ones, and perhaps some far seeing and enlightened benefactor, of sufficient means, may find in this direction the opportunity of rendering his name familiar in the annals of fame, by establishing a school of forestry, in its most comprehensive sense, for the systematic training of educators and practical engineers, in this inviting field of enterprise, and fully adapted to our American wants and ideas upon this subject.

However much the public may favor, there will still arise the need of laws to regulate, promote and protect the growth of wood; as we find laws necessary in the management of roads and bridges, or of any other great object of public utility. Let us consider some of the measures which a state might adopt for the promotion of this end, without interfering with personal rights, or stepping beyond the line which limits its duty in protecting the rights of its citizens.

1. By withholding from sale such wild and broken lands as might be returned from time to time for non-payment of taxes, when found chiefly or only valuable from the growth of timber, and by establishing laws for its protection, and for realizing to the state or to the county, whatever profits there might arise from the thinning out of timber, so as to preserve the tract as a forest. In this connection I would remark, that a more effectual vigilance would probably be secured, if the benefits belonged to the local administration of the place, as party jealousies and private interests would tend to keep officials under close surveillance, where a state officer, residing at a distance, and not personally known in the locality, would often find his authority ignored, and the public interests in his charge invaded. There should, however, be required an annual report to a state officer, clothed with ample power to enforce a rigid compliance with the laws upon the subject of forests.

2. By exempting from taxation for a limited time, and by offering bounties for, lands planted and enclosed for the growth of forest trees.

3. By offering bounties to counties, towns and individuals, for the greatest number of trees planted in a year, and made to live through the second season.

4. By requiring railroad, turnpike and other road companies,

where valid reasons to the contrary do not exist, to plant the sides of their roads with trees, or empowering town authorities, in case of neglect, to do this at their expense.

5. By imposing a tree-tax, payable in the planting of trees, or a fixed sum for each tree, to be expended only in planting trees. In cities and villages this commutation might be applied under local officers to the improvement of parks or other objects of public utility and ornament.

6. By protecting trees on the way-side, and in public places, as well as on private grounds, from wanton destruction, by adequate penalties, sufficient to restore the loss and pay the injury.

7. By requiring the elements of science applicable to forest culture to be taught in the public schools, and by encouraging it in academies and colleges. This, in the higher grades of schools, would embrace the most approved methods of cultivation, the influences of soil and climate, and the various mathematical, mechanical, physiological and chemical principles involved in the subject. Special schools under national or state patronage might ultimately be founded.

Congress has recently taken action tending to encourage the planting of forests in the territories, where most needed, but might do much more in promoting this great measure of public utility. A few of the states have also done something intended to advance the same object, but without uniformity, and as yet with but very limited result.

With respect to the failure of water supply for hydraulic power, navigation, or city use, until woodland shade can be restored to the sources, we must depend upon *reservoirs*, to retain the surplus floods of winter for summer wants. There are few streams or rivers in the country, where these might not be made to advantage, and in some cases greatly to the improvement of the natural capacity of these streams as they were first known. In the construction and maintenance of these reservoirs for navigable canals or for cities, they should obviously be under the same control as these works themselves, of which they are the essential part. But where needed for hydraulic power only, they could best be intrusted to the management of those who have an interest in them, and government should only provide, by general laws, for the organization and regulation of companies with the corporate powers necessary for their object. As in other cases where pecuniary

values are involved, the vote or power of each owner should be in just proportion to his interest, with the right of appointing a proxy to represent it when desired. Under suitable regulations of law, such associations could scarcely be perverted from their proper object.

There may be cases in which a state would be justified in making reservoirs to improve the hydraulic power of rivers, thus securing solidity of construction, and amplitude of size; and often such improvements might be made before any capital had been invested along the line, or where its amount was too feeble to warrant the expenditure; but the expense should ultimately be taxed upon the interests concerned, and the management should be given up to these interests, as soon as it can safely be done.

In the state of New York, measures have been begun for the preservation of forests, which I may briefly notice. An extensive region north of the Mohawk river and west of Lake Champlain, embracing over two million of acres of land, the Adirondack Mountains, and the sources of the Hudson and other rivers, lies an unbroken wilderness. More than a hundred years have passed since settlements were formed on its southern and eastern border, and more than seventy since it has been entirely surrounded by a belt of improvement embracing some of the best farming lands of the state. Although a scheme of speculation was far advanced before the close of the colonial period, for the settlement of this region, and great sums have since been wasted by capitalists in attempting to develop its agricultural resources, these efforts have uniformly resulted in failure; and, excepting in a few favored spots, the region is still as wild and picturesque as when it was known only as the hunting ground of the native Indian. This uniform failure may be justly ascribed to the scanty sterile soil which covers the surface where the surface is not the naked rock, and to the cold and forbidding character of the climate, due to great elevation and the influences of mountain ranges. Corn and the cultivated fruits would seldom ripen, from the frosts that may happen at any time in the summer, and only hay, oats and potatoes can be grown to advantage where the soil and exposure favor. Yet it is for the most part covered with timber, often of the finest quality, and it is supposed to abound in magnetic iron ores, of which mines are wrought with great profit near the eastern border.

Some twenty years ago, some railroad speculators secured from the state a grant of a quarter of a million of acres, at five cents an acre, yet failed to build the road, or to confer the advantages promised; and since this period almost the whole of the lands in this region have passed into the hands of lumbermen and tanners, leaving at present only about forty thousand acres in the seven counties wholly or partly included in the wilderness. Most of these lands have been repeatedly returned and sold for the non-payment of taxes, and if no more tax sales are held, a large portion will doubtless in a very few years again revert to the state. Through this wilderness lines of navigation extend through lakes and along rivers with slight portages, entirely across, from the Moose and Beaver rivers on the west, to the Saranac and Racket rivers of the northeast. For many years it has been the favorite haunt of parties of sportsmen and those seeking relaxation from the cares of business, by a few weeks' residence in summer, among the wild picturesque scenery and healthful climate of this region. Hotels for summer residence have been built upon the banks of lakes in various places in the interior, and many guides find employment in conducting parties along these rivers and lakes, and in furnishing the supplies and assistance they may need. Roads and telegraphs have been constructed to navigable points in the interior, and every year adds to the number of visitors to this great solitude of woods and waters.

In 1872, the Legislature of New York passed an act creating a Commission of State Parks, and appointing certain persons therein named to examine and report upon the expediency of vesting in the state, the title to the wild and timbered regions lying within Lewis, Essex, Clinton, Franklin, St. Lawrence, Herkimer and Hamilton counties, and to recommend such measures as might be deemed proper, relative thereto. The Commission was to continue two years, and there is a probability that it will be made permanent. Already, at its suggestion, the sale of lands for non-payment of taxes has been ordered to be discontinued, and thus the first step taken towards the accomplishment of its object. The commission will recommend no enclosed grounds, no salaried keepers, and no attempt whatever at ornamentation. There should be stringent laws and adequate penalties against spoliation of timber, or destruction from careless fires; and means of access from various places on lines of thoroughfare should be provided

and maintained. In some cases short canals, with locks for passing boats, might save the labor of a difficult portage, but beyond these there is scarcely more needed for the present.

There are, however, important questions involving the supply of water for the state canals; the preservation or restoration of hydraulic power on the rivers; and possibly the future supply of New York City, and the cities and towns along the Hudson with pure water, by an ample aqueduct, from the crystal fountains of the Hudson, which may be properly considered; and a fit opportunity is given for presenting in its strongest light, the importance of protecting forests, and of promoting the growth of trees, on account of their influence upon climate, and upon the general welfare of the state.

These questions are not limited to a particular state, but interest the Nation generally; and I would venture to suggest that this Association might properly take measures for bringing to the notice of our several State Governments, and Congress with respect to the territories, the subject of protection to forests, and their cultivation, regulation and encouragement; and that it appoint a special committee to memorialize these several legislative bodies upon this subject, and to urge its importance.

A measure of public utility thus commended to their notice by this Association, would doubtless receive respectful attention. Its reasons would be brought up for discussion, and the probabilities of the future, drawn from the history of the past, might be presented before the public in their true light. Such a memorial should embrace the draft of a bill, as the form of a law, which should be carefully considered in its various aspects of public interests and private rights, and as best adapted to secure the benefits desired.

Hints for the Promotion of Economic Entomology. By John L. LeConte, M.D., of Philadelphia.

It is indeed a most gratifying evidence of the increasing interest in the department of zoology which we cultivate, that the entomologists, now in connection with the "American Association for the Advancement of Science," are sufficiently numerous to

form a separate sub-section, and enough in earnest to make the meetings of the section of value to attract our widely scattered students.

I hail with joy the opportunity of being present at this meeting, and the more so, because absence from the country has prevented me from being with you on previous occasions, when you assembled to deliberate on the means necessary for the promotion of our favorite science; to communicate to each other that which you have done of best during the year, and call on your colleagues to rejoice with you over the gems of truth which Nature bountifully bestows on you and on all who visit with pure heart and humble mind her exhaustless treasury.

Believing, as I do, that the few days thus spent in closer communion, by those who are in sympathy in their main intellectual pursuits, should be devoted rather to mutual instruction and comparison of general views derived from our studies, than to the reading of essays on special or descriptive subjects, which sooner or later will appear in suitable places in scientific journals, I have thought it not inappropriate to give briefly some ideas suggested by a long course of investigation both in the field and in the museum, regarding the requisites for a more rapid advance of American entomology, and a more speedy development of the practical benefits which the science promises.

Before endeavoring, so to speak, to forecast the future, or to indicate those paths of research from which the most useful results may be expected, it would be well to glance at the past history of our science; so that by rapidly reviewing the steps by which progress has been made, we may be better prepared to estimate the comparative value of the agencies by which our present position has been attained.

The beginning of the American school of entomology may be considered as made in 1817 by Thomas Say, in those days the most generally instructed zoologist in the United States. Though his contributions to the literature of other departments of natural history were quite copious, yet entomology seems to have been his favorite science, and on his studies of the various orders of insects his scientific reputation must mainly rest.

At that time the text-books in entomology were mainly Fabricius, Herbst and Latreille, and the efforts of American naturalists in every branch were confined to adopting, without

independent criticism, the classifications and generic determinations of their European correspondents. Biology did not exist either in name or in idea. Careful observations of a few noxious species by Prof. Peck and Dr. T. W. Harris were the slight foundation upon which the whole structure of economic entomology was to be erected.

It will be readily seen then, that the entomologists of that early period were essentially *species men*, namers and describers of the unknown objects with which they were surrounded:—a work which was done so well that of the many hundreds of species described by Say, and the smaller number by his collaborators, scarcely any remain doubtful, and but few unknown.

Preëminent among the early naturalists of the United States, and far beyond any of them, both as an industrious collector, a careful observer in the field, and an intelligent investigator in the museum, was Dr. T. W. Harris, of Massachusetts. A man of singular modesty and diffidence, appreciated neither by himself nor by others, but whose memory will be cherished by all who knew him, and whose merits will be more and more recognized as time brings him with his limited opportunities more strongly in contrast with the other students of his day. Had he published, as he wrote, the independent investigations on classification which he made, or had the proper facilities been afforded him and the requisite stimulus given, our science in this country would have anticipated many of the schemes of arrangement developed later by the best European students.

Among the entomologists of that time, properly pertaining to our country, must be named Dr. C. Zimmermann, a German by birth, and trained to science before he made this continent his home. The monographs of *Zabrus* and *Amara*, published before leaving Europe, still remain thoroughly careful and classical studies of those genera, to which nothing has been or can be added except the descriptions of species since collected. It was a misfortune for our science that Zimmermann too, though a profound and laborious student, would never publish the results of his investigations. As a systematist in the science, he was of the very highest order, and I here cheerfully acknowledge my obligations to him for some of the hints which, afterwards more fully developed, have gained for several of my memoirs the generous approval of foreign entomologists. His manuscripts, submitted to

me in 1867 by his widow, contained a large part of a systematic work on Coleoptera, with descriptions of many hundred new species of the Southern States, which, however, had been rendered of no avail by recent publications, posterior to the manuscripts in question.

After the founders of the science in this country came a period of apathy, during which nothing was done. The work of description was then resumed by Melsheimer, Ziegler and myself, without, however, any attempt at independent study of classification or particular observation of life histories of the objects described.

The first serious monographic study made was that of the *Histeridæ*, published in 1845 by my father in the Boston Journal of Natural History, modelled on the *Monographia Histeroidum* of Paykull, and, like it, illustrated with outline figures of all the species.*

The second period in the history of American entomology now begins, in the decade from 1840–50; a most important epoch in the intellectual history of our country. An independent school of science had commenced in zoology by the investigations of James D. Dana on the polypes and crustacea collected while attached to the Exploring Expedition of Captain (now Admiral) Wilkes; in geology by James Hall of the New York Geological Survey, and by the brothers Rogers of the Pennsylvania and Virginia Surveys. Prof. Agassiz also came to us, introducing methods of systematic instruction, which previously each student, after many trials, had to invent by himself, and for himself alone; and with his unequalled ability as a lecturer to excite enthusiasm in his hearers, he added a powerful stimulus to the cultivation of natural history, the effects of which can hardly be exaggerated. With few exceptions, the zoological students who have since become prominent in the United States have been instructed for a longer or shorter period by him; and it has been a frequent cause of regret to me, that my early efforts

* I have purposely excluded from this sketch of American entomology the illustrated work of Boisduval and LeConte on the Lepidoptera of North America. Although the task of collecting material and making notes on the habits of larvæ with many drawings occupied my father, Major John LeConte, for several years, the text of the work and the systematic arrangement, such as it was, were prepared abroad, not at all under his control; and the work was stopped before the completion of the first volume. All the notes and drawings which were to have been used in the study of the Heterocera were retained by his coeditor, and still remain in Europe.

in science had not been directed by one who could so thoroughly combine kindness in instruction with firmness in criticism; who could so well temper the natural impatience for rapid publication of the young and inexperienced observer, to that calmness of judgment which permits nothing to be published until it expresses the best results which the author can at that time produce.

Another most valuable auxiliary to science in the United States, belonging to the same decade, was the establishment of the Smithsonian Institution, on a secure basis, and nearly in the form devised by its learned secretary, Prof. Joseph Henry; whereby the funds were employed chiefly in the assistance of investigators and explorers, and in the publication of scientific memoirs.

It has long been the privilege of those who labor to *extend* the boundaries of human knowledge to work hard and (in ordinary phraseology) to find themselves: and, until the organization of the Smithsonian Institution, it was their further privilege, in this country, to publish at their own individual expense all memoirs, which from bulk or cost of illustration were beyond the limited means of local scientific societies.

Under the fostering influence of this, among the most noble of the intellectual charities of the age, many valuable works on abstract science have been published; which, though produced in less than one-third of a century, by a small number of investigators, thinly dispersed over a large extent of territory, would do honor to older communities, in which students of science and their labors are not unfrequently cared for by the protecting influence of government.

It has thus come to pass that manuals and catalogues of several orders of insects have been prepared by the students best qualified to give, in a condensed form, compilations of the latest results of investigation, or entitled to put forth their own views of classification, as worthy of acceptance; and in the preparation of this series of works, valuable assistance has been rendered in orders which had not received attention from our native students, by some of the best European authorities on those subjects, among whom are specially to be remembered with gratitude Hagen, Loew, Osten-Sacken and De Saussure.

The excellence of the memoirs thus published by the Smithsonian Institution results from two facts; the persons invited to pre-

pare the works are those who are recognized by scientific men as most competent for the labor; and the memoirs when prepared are submitted to committees capable of judging of their value. Neglect of these precautions will probably ensure greater or less failure in attempts to procure works for either primary or advanced scientific instruction; and I am the more confirmed in this opinion by the miserable result attending the munificent expenditure of the state of New York, on the volume illustrative of insects injurious to agriculture. Compiled by a person ignorant of the science, and illustrated by a draughtsman untrained in natural history drawing, it remains a permanent example of misplaced confidence and liberality; an equal disgrace to the legislation, the science and the art, of the great state in which it was published.

The possibility of acquiring some knowledge of our insects, without the possession of large costly libraries which up to this period were indispensable, soon made the science more popular; and the names of the species beginning to be known, many persons were attracted to form collections, and others to the equally fascinating study of the life history of individual objects.

Thus arose the present condition of economic entomology; and the biological studies commenced years before by Dr. Harris were worthily continued by Dr. A. Fitch of New York, and the state entomologists afterwards appointed in several of the Western States.

Most prominent among those to whom we are indebted for the development of practical entomology was the lamented B. D. Walsh, of Rock Island, Illinois; an Englishman by birth, bringing to this country a mind well trained in classical and scientific instruction by a thorough University course, and animated by an enthusiastic love not only for science but for truth and consistency in life.

The "Practical Entomologist," a monthly magazine, published (1865 to 1867) by a committee of the entomological society of Philadelphia, was edited chiefly by him. Its successors, the "American Entomologist" and "American Entomologist and Botanist," of Saint Louis, were edited by Mr. Walsh, and Mr. C. V. Riley, the accomplished state entomologist of Missouri. These volumes will be often referred to, not only for the meritorious essays on injurious insects and for the excellent suggestions towards controlling these pests, but still more for the fearless and caustic manner in which the editors exposed many quack contrivances for

exterminating our insect enemies; thus endeavoring to protect our too credulous farmers against the pretensions of ignorant inventors and shameless empirics.

Last to be mentioned, because the most recent, of the aids for the cultivation of entomology, and for popularizing the science, is the "Guide to the Study of Insects," by Dr. A. S. Packard, Jr.; a most judicious and excellent compilation from the best works on the various orders, adapted to the North American fauna, and illustrated with copious and well drawn original figures, combined with no insignificant portion of the author's own investigations, chiefly in embryology.

Having now shown, by a hasty survey of the past, the gradual progress of our science, let us consult in regard to what is to be done to perfect the structure, the foundations of which are thus securely laid, and above all, what is necessary to popularize and utilize the great mass of information which has been obtained by so much labor.

Of all the branches of zoology, there is none more intimately connected with the great agricultural interests than entomology;* and yet from the vast number of objects involved in the study, many of which, on account of their small size, are with difficulty recognized by the untrained observer, and also from the complication of metamorphosis and habits such as are seen in no other department of the animal kingdom, there is no branch of natural history which requires for its elucidation greater industry, or higher powers of scientific analysis. For the same reasons, none of the inferior animals are so well fitted to elude and resist human control. We may therefore expect the practical application of the abstract truths and facts contained in the science to be a task of more than ordinary difficulty, requiring the assistance of the most learned students and the most ingenious investigators.

I may, perhaps, be accused of uttering a very vapid truism, when I assert that before any science is capable of rational practical application, the science must be well advanced, or at least its general principles and methods of investigation firmly estab-

*"The entire sum expended by Congress, or by our various State Legislatures for this purpose (from 1776–1869) cannot exceed $90,000 to 100,000, or about $1,000 a year. Yet the annual damage done by insects within the limits of the United States cannot be less than ($300,000,000) three hundred millions of dollars. Am. Entom. and Bot. ii, 109.

"Napoleon, at the summit of his prosperity, never inflicted more damage on a nation than the liliputian insect army inflicts on the United States." *Ibid.*, ii, 367.

lished; and further that the application must be made by those who are fully informed as regards the science. Yet, by neglect of this apparent axiom, we have seen that the great state of New York expended a sum of money, almost sufficient to print all the useful books on entomology since published in the United States, upon one quarto volume, which is a monument only of presumption and ignorance.

I may be excused, then, if I mention first those things which in my opinion will contribute to a more rapid advance in the descriptive and systematic portions of our science, and conclude with those relating to its future usefulness.

First, then, will come the completion of the series of works, published by the Smithsonian Institution, on the classification of the several orders. For this students must be found, who will devote themselves to the study of those orders which have been heretofore neglected. This series must be supplemented by synonymical and bibliographical catalogues, and finally by synopses of species in each order, to which supplements must from time to time be made, to diminish as far as possible the necessity of reference to other works, and thus place the accurate results of science within reach of persons who can ill afford the costly libraries now necessary for reference.

Second, and equally important, will be the formation of *type* collections for the identification of species. The number of species is so vast, the differences so small, and the multitude of new forms, not yet represented in collections, so great, that the best descriptions that can be written do not obviate the necessity of referring at times to the original types for comparison, and the amount of time, labor and expense saved to students, by having the whole of the information within reach at one place for each order of insects, can scarcely be estimated.

These type collections should be in the possession of the student who can make best use of them for the present interests of science, and on his death, or retirement from intellectual pursuits, should *not be exposed for sale*, or to any other vicissitudes of fortune, but should be given to his successor in science, or placed in some public institution where they will be *most carefully preserved* and *used only for reference.*

The liberality of friends, both at home and abroad, has already made my collection of coleoptera such a type collection, and with

the exception of a moderate number of species described in Europe, of which no duplicates can be obtained, and a very small number which I have described from other collections, at the solicitation of their owners, it contains types of nearly all the described coleoptera of America north of Mexico. From the saving of time both to students who visit my collection, and to myself in naming series for correspondents, I cannot too strongly recommend the formation of similar collections in other orders of insects.*

The last portion of our subject yet remains to be discussed: the practical application of the great mass of scientific truth which has been thus far gathered in relation to the structure, classification, habits and life history of insects.

Of the immense number of insects which are found in any given portion of the earth's surface, comparatively few are capable of becoming so numerous as to affect plants injuriously. But from time to time, the interference of man in the progress of civilization destroys the balance which previously existed, and insects, before unimportant by reason of their comparatively small numbers, finding the checks to their increase removed, suddenly become very destructive to one or another of our agricultural products. In this case what is to be done? Obviously there are but two courses; the first to abandon the crop, until the insect enemy is reduced by starvation to its former insignificance; the other is to establish, by human intelligence, a system of checks to take the place of the divine machinery which has been interfered with by the same human intelligence. The second is the course that is, and probably will continue to be, generally adopted.

This new system of checks, according to the habits of the insect to be suppressed, may be divided into (1) those requiring personal labor and diligence alone; (2) personal labor assisted by contrivances; (3) automatic contrivances, not requiring personal attention (including the use of poisons); (4) the production of diseases; (5) the introduction of parasites and other enemies.

Under the 1st head may be mentioned the destruction of larvæ

*As a proof of the earnestness of this recommendation, as well as a duty I owe to those interested in the progress of the science, who have coöperated with me in placing their types in my collection, I hereby pledge myself that my collection shall never be sold or divided, but that it shall be placed permanently where it can be best cared for, and made accessible for the authentication of specimens. And I invite those who are willing to sacrifice rarities, or even uniques in their collections for such a purpose, to send them to me, with the full confidence that they are thus rendering them of more general use than they can be in local collections.

of borers by wires, etc.; 2nd, the collecting of plum weevils, potato chrysomelæ, etc., by large nets, and their subsequent destruction; 3rd, sugaring with poisoned food, specially applicable to nocturnal lepidoptera, and the use of fires, or lanterns with a vessel of poison, to attract nocturnal species; 4th, the communication of fungoid disease (like *pebrine*, which affects the silkworm) to other lepidopterous larvæ;* 5th, introduction and preservation of insectivorous mammals, birds, reptiles and insects according to the particular indication of the case; and the transportation of parasites known to affect the pest in other localities.†

In the last annual report of Mr. C. V. Riley, Missouri state entomologist, there is a very effective comparison of the ravages made by the gregarious insect pests with the destruction caused by an invading army. The same simile has been frequently used by me in conversation, and has doubtless often occurred to many of you. The application of it made by Mr. Riley is that, if an enemy were to cause a small fraction of the injury which results each year from the depredations of even one of several of our insect enemies, the whole country would resound with a clamor for the suppression of the invaders. The memory of a colossal conflict is, alas! still fresh in our minds, and I desire not to awaken the painful recollections which rest in the bosoms of us all; but leaving out reference to the distressing scenes which we have all witnessed, there was much of the ludicrous, from which we may on this occasion derive profit, or at least the material for carrying our simile somewhat farther.

Putting out of view for the moment the noble patriotism of the uncorrupted and incorruptible masses of our nation, prominent among whom were the great agricultural class, whose interests it is the object of the present inquiry to protect, we all remember vividly the eager struggle of small politicians for staff appointments, of greater politicians, innocent of martial training, for higher commands; the zeal of contractors to furnish supplies for the soldiers in the field (sometimes, as in the case of shaving soled

* I am extremely hopeful of the result of using this method. I have learned of an instance in which from the communication of the disease by some silkworms, the whole of the caterpillars in a nine-acre piece of woods were destroyed.

† I learn from the 3rd annual report of Dr. W. LeBaron, Illinois state entomologist, that in accordance with ideas first published by Mr. B. D. Walsh, a Chalcideous parasite of a coccus which attacks the apple tree, has probably been successfully introduced into the northern part of the state, where it was previously unknown. (*Op. cit.* p. 200).

shoes, and shoddy garments, rather aggravating than relieving their sufferings); the general hurry and scurry, and bustle and turmoil, to do everything hastily and with the greatest pecuniary profit.

Why was all this? Was the great glory to be obtained in military service, when man fights man, the stimulus? Is there not equal glory in the more laborious, albeit peaceful combats of science, when man subdues the inorganic or the organic powers which resist his will, and makes them subject to his control? Or is it, perhaps, to use a common phrase of the period, because there was money in it?

If the latter be a part of the cause of the agitation to which we allude, let us see if the same idea cannot be utilized for our present purpose. There is money, aye, much money, in any well devised scheme for the practical application of entomology to the protection of agricultural interests. First, there is the saving of untold millions in the productions of the country, now destroyed by insect pests. Second, there is the necessity for the expansion and reorganization of the Department of Agriculture, so that it will represent and protect the farmers, to the same extent that the Coast Survey protects the commercial interests of the nation.

In this expansion and reorganization of the Department of Agriculture the controlling power should be the highest scientific ability that can be procured for the place, and the office should cease to be as it has been since its establishment, a semi-sinecure for persons of small or local political influence. New places would have to be created, but with a moderate sprinkling of good working scientific men, many of these might be regarded like other offices, as the spoils of the dominant political party, and the interests of the farmer still be protected. Better would it be, though, if the latter class should demand that the government give them a thoroughly organized, compact, industrious body of the best trained scientific men, to teach them what should be done to control the destroyers of their labor.

There is now lying idle in Washington a great mass of notes on habits of injurious insects, collected by the untiring exertion of Mr. T. Glover, the industrious entomologist of the Department of Agriculture. This material, in its present imperfect form, if arranged under proper scientific supervision, and illustrated by figures submitted to judicious criticism, and then published in the same careful manner as the explorations of the Engineers, the

Coast Survey, and other scientific departments of the government, would be of great utility in preparing the condensed reports, which should finally be accessible to every intelligent agriculturist.

One more illustration, and we will dismiss this already somewhat prolix simile of the invading army.

As in all such cases of aggression, it is competent with the higher military authorities to take private property for the benefit of the nation; so, too, a power similar in its results, though less despotic in its exercise, is necessary in our contests with the organic "powers of the air," which attack our fields. How this authority is to be localized and manifested admits of much discussion, to enter upon which would tax your patience, and prolong this discourse far beyond the limits to which I intend to confine it. For the moment, the following may be suggested, with some modifications, as probably feasible in the extreme cases, fortunately few in number, which may be exemplified by such destructive attacks as the army or boll-worm upon cotton; the Hessian fly upon wheat; Scolytidæ (bark borers) upon pine forests; and the curculio upon plums and allied fruits.

The establishment of a fund, by the assistance of the federal government, state, or county authorities, or by private combinations, from which are to be paid owners of infected crops, which *are destroyed in order to prevent the spread of the infection.* This must of course be done under the advice of intelligent and carefully chosen agents of the authority by which the fund is to be dispensed. The rate of compensation could be easily determined at the end of the season by the average value or yield of similar crops in the vicinity, and should be such a liberal fraction of the full value, as would stimulate the owner of the property to be destroyed to declare the infection at the earliest possible moment, but at the same time not so large as to prevent due diligence on his part to confine the infection within the smallest limits.

Besides these two measures, which I consider of primary importance, there are several others, more easily under present control, by the adoption of which our accurate knowledge of the really formidable insect pests can be greatly increased, and the means for their suppression intelligently and efficiently applied. With a condensed statement of them, I shall conclude my discourse, thanking you for the kind attention with which you have favored me.

1. Reorganization of the Department of Agriculture, on a scientific basis, for the proper protection and advancement of agricultural interests.

2. Preparation of lists of the most destructive insect pests, with condensed notes of what is now known concerning them, that attention may be directed specially to those investigations necessary to complete our knowledge.

3. Coördination and coöperation of state entomologists with the chief of the Department of Agriculture, that they may work harmoniously and intelligently in concert, and thus avoid the waste of labor now resulting from duplicate observations and repetitions in publication: collateral to this, the publication each year of a brief report containing such important advances made in the science, both at home and abroad as should be made known to the farmers.

4. Accurate calendars to be prepared of the appearance, disappearance and other phenomena of the history of the most injurious insects in different parts of the country.

5. Contrivance of apparatus on a large scale, by which, with the least expenditure of material and labor, the nocturnal species may be attracted by light, and dropped into a vessel containing cyanide of potassium or other poisonous substance.

6. Experiments on the effects of poisons upon those species whose habits permit the wholesale application of such means of destruction: especially adapted to nocturnal lepidoptera by the process known as sugaring for moths.

7. Careful study of epidemic diseases of insects, especially those of a fungoid nature: and experiments on the most effective means of introducing and communicating such diseases at pleasure.

8. The preparation by our best instructed entomologists working in concert, of one or more elementary books suitable for use in schools, giving in a compendious form the general principles of the science, and indications for applying the knowledge to practical results.

9. The appointment in agricultural colleges of competent professors of entomology, who have been trained in a scientific school, to fit them for the duty of instruction.

10. The establishment of the means of compensation for compulsory or voluntary destruction of crops infected by formidable pests, as above mentioned.

NOTE ON BUFO AMERICANUS. By THOMAS HILL, of Portland, Me.

THIS note is intended as a contribution toward the psychology of the American toad; simply presenting some evidences of intelligence and of capacity for learning to which I have been witness.

In the summers of 1843–5, an old toad used to sit under the door of a beehive every fine evening, and dextrously pick up those bees which, overladen or tired, missed the doorstep and fell to the ground. He lost, by some accident, one eye, and it was observed by several members of the family, as well as myself, that he had with it lost his ability to pick up a bee at the first trial; his tongue struck the ground on one side the bee: but after several weeks' practice with one eye he regained his old certainty of aim.

I have never seen our toad use his hands to crowd his food into his mouth as the European toad is said to do; although he uses them freely to wipe out of his mouth any inedible or disagreeable substance. When our toad gets into his mouth part of an insect too large for his tongue to thrust down his throat (and I have known of their attempting full grown larvæ of *Sphinx quinquemaculatus*, and even a wounded hummingbird) he resorts to the nearest stone or clod and presses the protruding part of his mouthful against it and thus crowds it down his throat. This can be observed at any time by entangling a locust's hind legs together and throwing it before a small toad.

On one occasion I gave a "yellow-striped" locust to a little toad in its second summer, when he was in the middle of a very wide gravel walk. In a moment he had the locust's head down his throat, its hinder parts protruding; and looked around for a stone or clod, but finding none at hand, in either direction, he bowed his head, and crept along, pushing the locust against the ground. But the angle with the ground was too small and my walk too well rolled. To increase the angle he straightened his hind legs up, but in vain. At length he threw up his hind quarters, and actually stood on his head, or rather on the locust sticking out of his mouth, and after repeating this once or twice succeeded in "getting himself outside of his dinner."

But these instances of ingenious adaptation to the circumstances were exceeded by a toad about four years old at Antioch college. I was tossing him earthworms while digging, and pres-

ently threw him so large a specimen that he was obliged to attack one end only. That end was instantly transferred to his stomach, the other end writhed free in air, and coiled about the toad's head. He waited till its writhings gave him a chance, swallowed half an inch, then taking a nip with his jaws, waited for a chance to draw in another half-inch. But there were so many half-inches to dispose of that at length his jaws grew tired, lost their firmness of grip, and the worm crawled out five-eighths of an inch, between each half-inch swallowing. The toad, perceiving this, brought his right hind foot to aid his jaws, grasping his abdomen with his foot, and, by a little effort, getting hold of the worm in his stomach from the outside; he thus by his foot held fast to what he gained by each swallow, and presently succeeded in getting the worm entirely down.

A garter-snake was observed this summer in North Conway pushing a toad down his throat by running it against clods and stones; just as the toad crowds down a locust.

The amount which a toad can eat is surprising. One Tuesday morning I threw a *Coreus tristis* to a young toad, he snapped it up, but immediately rejected it, wiped his mouth with great energy, and then hopped away with extraordinary rapidity. I was so much amused that I gathered some more of the same bug and carried them to a favorite old toad at the northeast corner of my house. He ate them all without making any wry faces. I gathered all that I could find on my vines, and he ate them all, to the number of twenty-three. I then brought him some larvæ of *Pygæra ministra*, three-quarters grown, and succeeded in enticing him to put ninety-four of them on top of his squash bugs. Finding that his virtue was not proof against the caterpillars when I put them on the end of a straw and tickled his nose with them, he at length turned and crept under the piazza, where he remained until Friday afternoon, digesting his feast.

A gentleman having read this paper told me he had seen the toad tuck in the last inch of an earthworm with his hand, European fashion. I then remembered that I have several times seen our toad put the last quarter-inch of earthworms in with his hand; but never saw him take his hand to a locust.

ALS AND GREEN MOUNTAIN GNEISSES OF
By J. D. DANA, of New Haven, Conn.

e "American Journal of Science" in noticed by Percival, that crystals alisbury, Connecticut, in mica schist the Stockbridge or Canaan limestone. nd in southern Canaan, at a locality in Falls e Housatonic River (to which I was directed Reed of Pittsfield), crystals of this mineral in a , well-characterized mica schist; but in this case, the *verlies* the limestone and is, therefore, the newer rock.* s staurolitic mica schist contains also small garnets. The order of superposition is free from all doubt, for the Canaan limestone outcrops at the bottom of the same hill, from beneath the schist, and the dip is not over fifteen degrees.

The age of the Stockbridge limestone is admitted by all recent writers on the subject to be Lower Silurian. Logan referred it to the Quebec group or the formation next below the Chazy. But since then Billings has described fossils from the same limestone at West Rutland, which he has identified as Chazy. And the Crinoids and other species, mentioned in the "Vermont Geological Report" as found in the limestone at other Vermont localities appear to show, as long since suggested by Professor James Hall, that the Trenton limestone is also present in the formations. The Chazy and Trenton limestones (Black River included) follow one another in New York, and the west and south. That the Canaan limestone is the same identical stratum that occurs at Stockbridge in Massachusetts, and farther north at Pittsfield, I know from a personal tracing of the rock throughout this region; and examinations still farther north in Massachusetts and Connecticut lead me to believe in the conclusion of the geologists of the Vermont survey, that all is one formation—the Stockbridge limestone, or the Eolian as Hitchcock named it.

The fossils found in Vermont lead to the conclusion that the limestone represents the Trenton era as well as the Chazy. The overlying mica schist and other associated rocks have a thickness of at least three thousand feet; and, if the limestone is Trenton

*From facts I have observed elsewhere, I think it probable the Salisbury schist is also an *overlying* rock.

in part, they belong to an era later: either to a closing part of the Trenton period, or to the period of the Hudson River or Cincinnati group.

In any case there is no reason to doubt that the staurolites occur in rocks of the later part of the Lower Silurian age, and strong reason for the conclusion that these schists are in age veritable Hudson River rocks.

On this view, the Hudson River or Cincinnati group, in the Green Mountains — alike in Connecticut, Massachusetts and Vermont, — includes beds of quartzite, mica schist, chloritic mica slate, hydro-mica slate (the talcose slate of the earlier geologists), well-characterized gneiss of various kinds, some of it much contorted, and granitoid gneiss.

At a locality at South Canaan village, in Cobble Hill, the lowest rock over the limestone is quartzite; next follows mica schist passing into gneiss; and above this there is a light-colored granitoid gneiss, breaking into huge blocks with very little of a schistose structure.

Near the boundary of the towns of Tyringham and Great Barrington, four miles east of the latter village, a locality long since studied by Mr. R. P. Stevens of New York, and by him pointed out to me, there are, over the limestone, alternating beds of quartzite gneiss and limestone dipping at a small angle to the eastward. Commencing below, the succession is

1. Granular limestone, that of the valley.
2. Mica schist, a thin bed.
3. Hard jointed quartzite, 30 feet.
4. White granular limestone, 60 feet.
5. Hard jointed quartzite, 20 feet.
6. Gneissoid mica schist, 30 feet.
7. Bluish granular limestone, 40 feet.
8. Mica schist, 6 to 8 feet.
9. Quartzite, partly laminated, 120 feet, forming a high bluff,—the site of Devany's hearthstone quarry; and then
10. Gneiss, forming the top of the bluff, and having great thickness in a ridge to the northeast, but in its upper portions becoming very silicious or in part quartzite.

The fact that quartzite, limestone and gneiss or mica schist here alternate with one another is beyond question; and, if I am right in the age of the deposits above suggested, the alternations occur at the junction of the Trenton and Hudson River formations.

The above section occurs on the east side of a small open valley. On the west side of the same valley the foot of the bare front of

the hill consists of quartzite, dipping slightly to the north-westward, as if one side of a very gentle anticlinal of which the rock of the Devany quarry is the opposite. The quartzite, although hard and generally pure, contains a layer of mica schist ten inches thick which becomes pure quartzite a hundred feet to the eastward. Above the quartzite follows gneiss, which continues westward three miles, in a shallow synclinal, to Great Barrington, and there this gneiss is overlaid by a second thick stratum (100 feet or so) of quartzite. Here, then, there are two strata of quartzite separated by two or three hundred feet of gneiss, the whole overlying the Stockbridge limestone. The gneiss is a very firm rock, covering the slopes in some places with blocks like houses in size, where upturned through the growth of trees. I had suspected that it was one of the older gneisses of New England, until I found that it was overlaid by quartzite, and, on tracing further the stratification, proved that it belongs unquestionably to the series of rocks newer than the limestone.

From the facts which have been presented it follows that all old-looking Green Mountain gneisses are not præ-silurian, and, further, that the presence of staurolite is no evidence of a præ-silurian age.

THE SLATES OF THE TACONIC MOUNTAINS OF THE AGE OF THE HUDSON RIVER OR CINCINNATI GROUP. By J. D. DANA, of New Haven, Conn.

IN my study of the Stockbridge limestone and the associated rocks in Berkshire county, Massachusetts, I have found that the ridges are often, if not always, synclinals. They consist of the slates or schists (and sometimes quartzite) overlying the limestone; and in the downward flexures of the limestone, during the period of disturbance and metamorphism which made the mountains, the overlying beds or part of them were folded together into a compact mass which has withstood degrading agents, while the same beds in the anticlinals or upward flexures were extensively broken and have disappeared. The slate ridges are then nothing but squeezes of the slate formation between the sides of a limestone synclinal.

The Taconic mountains lie on the western border of the Berkshire limestone region; and, in general, the dip of the limestone, as well as of the Taconic slates is to the eastward, and hence the slates being underneath are seemingly the older. They are actually so, unless the Taconic ridges are also synclinals, with an eastwardly inclined axis, like some of the Berkshire mountains. Until recently I had regarded the apparent order of superposition as the true order of succession, that is, I had supposed that the limestones were newer than the Taconic slates. The conclusion seemed to be confirmed by finding at different places the slates and limestone with the same high easterly dip, the slates undermost.

But a few weeks since, on an examination of the eastern base of Mt. Washington, the highest part of the Taconic range in southwestern Massachusetts, along the road just east of the highest summit, called Mt. Everett, 2,634 feet in height above the sea, the limestone of the Sheffield plain was found to have, instead of the usual easterly dip, a *westerly* dip, and this continued up the slopes of the mountain as far as the limestone extended, about 120 feet above the plain and there the limestone was seen to pass directly beneath the slates of the mountain, these having the same dip and strike, the dip 20° to 25.° Thus the limestone was seen to descend under Mt. Washington and the slates to be the superior rock. Following along the base of the mountain northward, this dip of the Stockbridge limestone under the mountain was found to continue for nearly four miles, that is, along the whole eastern front.

These facts seem to prove that the limestone of Berkshire goes under Mt. Washington and comes up in the great limestone of Copake on the west side of the Taconic range.

I might show that there are probably two close-pressed synclinals in the Mt. Washington plateau (which is four to five miles broad), with steep easterly inclined axes, and that these synclinals are synclinals of slate riding over a single broken synclinal of limestone; that, to the north of the mountain, where the mountain descends to the limestone plains of Egremont, these synclinals become separated and include an anticlinal of limestone, the limestone of the anticlinal appearing in the intermediate valley while the ridges (synclinals) are slate; and that the two synclinals have an eastwardly inclined axis, the dip being very

steep to the eastward. But to explain fully would require diagrams, and I leave the details for another place.

Graylock in northwestern Massachusetts, to the east of the line of the Taconic, and 3500 feet in height, whose rocks are much like those of Mt. Washington, is described by Emmons as a synclinal; and, after a survey of the facts on the ground, observing the westerly dip of the limestones of the eastern slopes near South Adams, and the easterly dip on the western slopes near the entrance to the "Hopper," as the great central valley is called, I am satisfied that he was right. The dip at the summit and most other parts is very steep to the eastward. It appears then to be a result, like many other Berkshire Mountains, of a squeeze of the slates in a synclinal; and like Mt. Washington it is probably not a simple synclinal. It may be a double one, with the Hopper corresponding to the intermediate anticlinal, the beds of the whole having a high dip to the eastward owing to the eastward inclination of the axis of the folds. At North Adams, in the ridge of slate just west of the village, the limestone and slate both dip eastward, there being here the north end of one of the inclined synclinals.

The making of the highest summits of the Taconic region appears thence to have depended on this doubling of the folds. It becomes exceedingly difficult in such cases to ascertain the true thickness of the slate formation.

In view, then, of the facts stated in my former article with regard to the age of the limestone and its overlying rocks, it is not easy to avoid the conclusion that *the Taconic slates are Hudson river slates*, as long since held by the Professors Rogers; and, also, that the rocks, on which Prof. Emmons, in his New York Geological Report, first based his Taconic system, or out of which he devised it, are after all nothing but the Hudson river and Trenton groups, with the underlying Chazy. The Trenton limestone and Hudson River or Cincinnati groups, which properly constitute one series in American Geological History, are then *the true Taconic system.*

Farther Observations on the Embryology of Limulus, with Notes on its Affinities. By A. S. Packard, Jr., of Salem, Mass.

In a recent paper on the Development of Limulus, published in the "Memoirs of the Boston Society of Natural History," I stated that the blastodermic skin, just before being moulted, consisted of nucleated cells, and also traced its homology with the so-called amnion of insects. I have this summer, by making transverse sections of the egg, been able to study in a still more satisfactory manner these blastodermic cells and to observe their nuclei before they become effaced during and after the blastodermic moult.

On June 17th (the egg having been laid May 27th) the peripheral blastodermic cells began to harden, and the outer layer, that destined to form the "amnion," to peel off from the primitive band beneath. The moult is accomplished by the flattened cells of the blastodermic skin hardening and peeling off from those beneath.

During this process the cells in this outer layer lose their nuclei, and, as it were, dry up, contracting and hardening during the process. This blastodermic moult is comparable with that of Apus, as I have already observed, the cells of the blastodermic skin in that animal being nucleated.

This blastodermic skin in its mode of development may also safely be compared with the "amnion" of the scorpion as described and figured by Metznikoff, and we now feel justified in unhesitatingly homologizing it with the "amnion" of insects, in which at first the blastodermic cells are nucleated, and appear like those of Limulus. Moreover the layer of germinal matter, from which the blastodermic skin moults off, may be compared with the primitive band of insects. On June 19th, in other eggs, the cells of the blastodermic skin were observed to be empty, and the nuclei had lost their fine granules, and were beginning to disappear. The walls of the cells had become ragged through contraction, and in vertical section short peripheral vertical radiating lines could be perceived.

At this time an interesting phenomenon was observed. In certain portions of the blastodermic skin, or amnion, the cells had become effaced, and transitions from the rudiments of cells to those fully formed could be seen. From this we should suppose that the retention of these cells in the amnion of Limulus is due

to the singular function this skin is destined to perform, *i.e.*, to act as a vicarious chorion, the chorion itself splitting apart and falling off in consequence of the increase in size of the embryo. In insects these cells disappear, and after the skin is moulted it appears structureless.

From studies afterwards carried on in the laboratory of the Anderson School of Natural History, on the anatomy of the adult Limulus, I have been able fully to confirm the important discovery of Prof. Owen (Lectures), 1852, and more recently confirmed and greatly extended by M. Alphonse Milne-Edwards,* relative to the sheathing of the nervous cord and its branches by a system of arteries, and I would here bear testimony to the accuracy of Edwards' drawings and descriptions. Moreover I have been able by a study of living Limuli, beautifully injected by Mr. Bicknell by the kind permission of Prof. Agassiz, the director of the Anderson School, to extend still farther the anatomical researches of Milne-Edwards. With Mr. Bicknell's aid I have ascertained the existence of still smaller arterial twigs, on the peripheral subcutaneous portion of the body, than indicated by Milne-Edwards, and have made out the existence of an extensive series of vessels in the respiratory abdominal feet. For this I was prepared by a study of the respiratory lamellæ, which, in the arrangement of their chitinous septa, may be closely homologized with the gills of Amphipod Crustacea, as observed in living specimens without injection.

With the new information afforded us by A. Milne-Edwards, regarding the relations of the nervous cord with the ventral system of arteries, and the remarkably perfect circulatory system, so much more highly developed than that of any other Arthropod, I should no longer feel warranted in associating Limulus and the Merostomata generally with the Branchiopoda, but regard them, with the Trilobites, as forming perhaps a distinct subclass of Crustacea.

Certainly if we consider the relations of the anatomical systems to the walls of the body, the disposition of the segments forming those body walls, and the nature of the appendages, Limulus is built on the crustacean type. Because its nervous cord resembles that of the scorpion, and its circulatory system is more perfect than that of any Arthropod we know, this is no reason for assuming that it is not a Crustacean. On the same ground Cera-

* Recherches sur l'Anatomie des Limules. Annales des Sc. Nat., 1873.

todus is not a fish because it has the lungs of a reptile, nor is Ornithorhynchus a Saurian because it has the shoulder girdle of a Saurian.* I have, moreover, shown that some important features in the embryology of Limulus are like those of the scorpion and the hexapodous insects, the "amnion" of Limulus apparently being homologous with that of the insects.

In fact Limulus seems to me to be a synthetic or comprehensive type, bearing the same relations to the Crustacea that Ceratodus does among the fishes, or Archæopteryx among the birds; and because Limulus has strong analogies to the Arachnida, we should not overlook its true affinities with the Branchiopodous Crustacea.

Limulus may, then, be regarded as a Crustacean with the carapace of Apus, bearing simple and compound eyes as in that Phyllopod, with the antennæ foot-like as in many Entomostraca, and the abdominal appendages truly crustaceous in their structure, while the circulatory system is not fundamentally unlike that of other Crustacea, but only more perfect, and the digestive system is throughout comparable with that of the normal Crustacea; finally, its nervous system closely resembles that of certain Arachnida.

On a Remarkable Wasp's Nest Found in a Stump, in Maryland. By P. R. Uhler, of Baltimore, Md.

The insects of the genus Polistes have not hitherto been reported to make nests of clay. All the North American species have been considered paper-nest-builders. Many species are known from the United States, Canada and the West Indies, and these are generally of a brown or yellow color, having spots or bands either lighter or darker.

In the present instance we have a dark brown species with narrow yellow bands across the abdomen, and with yellow feet, which builds a nest of clay in the form of a cylinder. In the stump of a decayed Liriodendron, found by O. N. Bryan, Esq., in Charles county, Maryland, a number of these insects had aggregated their cylinders. The stump was about two feet in diameter and the

*I have been reminded by Professor Wyman of this peculiarity in Ornithorhynchus as stated by Meckel.

central cavity (which had been formed by the borings of large beetles) was five inches wide. In this, attached to the sides, sometimes lying flat in the grooves left by the beetles, or standing off at a considerable angle, and attached by their bases, were thirty-three of these peculiar structures. They were of a yellow clay, generally about half an inch in diameter, and varying in length from two to five inches. Sixteen of these were attached in one group projecting from the side of the cavity, and towards their outer ends were bent into a blunt curve, resembling a colony of the tubes of Serpula.

The nest, or, more properly, receptacle for the egg and young, is constructed in this manner. The adult Polistes flies to an adjacent place where there is suitable wet clay, works this substance into an oval pellet and flies to the place where the building is to be made. The pellet is then laid obliquely and pressed down by the fore feet and head of the insect so as to cause it to adhere firmly to the surface on which it is building. This operation is repeated until it has formed a cylinder about one inch in length. As it proceeds, it smooths the inside of the cylinder by working with its jaws and pushing the front of its flat head against the plastic clay. The first section being thus finished to its satisfaction it flies off to secure small spiders. It seizes a spider with its fore feet, stings it in just such a way as to paralyze, without destroying its life, and then deposits it in the bottom of the cylinder. An egg is then laid beside the spider, and the wasp flies off to secure other spiders. This is continued until the cavity, which generally holds from twelve to fifteen of the smaller kinds, is full. The wasp then proceeds to cover the open end with a cap of the same material as before, after which it adds other sections to the number of three or four, filling each with spiders, and depositing one egg in each. The young larva feeds on these paralyzed spiders, and, as it seems, requires from twelve to fifteen of them to nourish it until it is ready to become a pupa.

Unlike the species of Pelopæus, which also make clay nests, it does not nurse its young, but they are securely sealed up in the sections to feed themselves. When ready to come forth, the wasp gnaws a round hole in the wall of its cell, and flies forth as a perfect insect.

A similar, if not identical, species was very troublesome in Baltimore during the early part of last summer.

On the front walls of the Peabody Institute these wasps assembled in considerable numbers; and constructed their cells in the grooves of the joints of the marble. Their clay cylinders were so numerous as greatly to disfigure the marble and render it necessary to have the front of the Institute cleaned.

ON RECENT ADDITIONS TO THE FISH FAUNA OF MASSACHUSETTS. By THEODORE GILL, of Washington, D.C.

IN the first trustworthy enumeration of the fishes of Massachusetts, the report of Dr. D. H. Storer, published in 1839, only one hundred and seven nominal species were specified, ninety-one of which were salt or brackish water, and this number included several doubtful or "bad" species. Subsequently Dr. Storer, from time to time, made known additional forms, and in his "History of the Fishes of Massachusetts," completed in 1867, one hundred and thirty-four species were described and illustrated; of these, one hundred and sixteen are salt or brackish water forms, and eighteen fresh water. In an appendix to this work, however, twenty-one additional species were catalogued by Mr. Frederick W. Putnam, among which are included seven species made known from collections in the Smithsonian Institution, due chiefly to Prof. Baird. Since that time Prof. Baird, as United States Commissioner of Fish and Fisheries, while stationed at Wood's Hole, has been instrumental in bringing together twenty-three additional species, all of which are represented now in the collections of the Smithsonian Institution. These species belong to the following groups:

DIODONTOIDS, or porcupine fishes; one species, viz.: *Chilomycterus geometricus.*

ECHENEIDOIDS, or "suckers;" two species, viz.: (1) *Leptecheneis naucrates*, and (2) *Rhombochirus osteochir.*

COTTOIDS, or sculpins; one species, viz.: *Cottus Mitchilli.*

LOBOTOIDS; one species, viz.: *Lobotes Surinamensis.*

ELACATOIDS; one species, viz.: *Elacate Canadus*, said sometimes to be called crab-eater.

Xiphioids, or sword-fishes; two species, viz: (1) *Tetrapturus albidus* and (2) *Histiophorus gladius.* These are of peculiar interest, as neither had been previously signalized as inhabitants of our waters, but both, if we may rely on the fishermen, are regular denizens along the coast, at least in summer, and have received the name of bill-fish. The former is readily distinguished from the common sword-fish by the long dorsal fin and ventrals, and the latter by the very high dorsal fin, as well as by the ventrals. Three specimens of the *Tetrapturus* have been obtained for the Smithsonian Institution, and several others have been procured by other persons. Only one of the *Histiophorus* has been obtained, the animal being caught with difficulty; but it is distinguished by the fishermen on account of its elevated dorsal.

Scombroids; two species, viz.: (1) *Cybium regale*, and (2) *Orcynus alliteratus.* The first is known as the cero or kingfish, and is closely related to the famed Spanish mackerel, but attains a larger size and is spotted with black instead of yellowish; it is inferior as food to the Spanish mackerel. The second is a small tunny, and was never before known to visit any portion of our coast; but in 1871 large numbers came in, making their appearance about the middle of August, when they were first caught in small numbers, but afterward by hundreds; they were quite uniform in size, averaging about fourteen pounds; their flesh is dark and very poor.

Carangoids; with five species, viz.: (1) *Decapterus punctatus*, (2) *D. macarellus*, (3) *Trachurops crumenophthalmus*, (4) *Carangus hippos* and (5) *Blepharichthys crinitus.* These are all small fishes, and interesting chiefly to the ichthyologist on account of their northern range. The latter, however, is remarkable for the greatly prolonged and flexible rays of the dorsal and anal fins, and six or seven sent to the Smithsonian Institution were so inextricably intertangled by their rays that an assistant was obliged to spend two hours in disentangling them. The pampano (*Trachynotus Carolinus*), although previously found by Prof. Baird in its young stage, was for the first time obtained so far north in its adult condition.

Exocœtoids, or flying fishes; one species, viz.: *Exocœtus melanurus.*

Conorhynchoids; one species, viz.: *Conorhynchus macrocephalus*, the lady fish.

ELOPOIDS; one species, viz.: *Elops saurus.*

ACIPENSEROIDS; one species, viz.: *Acipenser brevirostris*, the blunt-nosed sturgeon.

MYLIOBATOIDS; one species, viz.: *Rhinoptera quadriloba*, the cow-nosed ray.

TRYGONOIDS; one species, viz.: *Pteroplatea maclura*, the butterfly ray.

GALEORHINOIDS; two species, viz.: (1) *Eulamia Milberti*, the common shark of the New York waters; and (2) *Galeocerdo tigrinus*, the tiger shark. The latter, although previously known as an inhabitant of the southern coast, had not been known to occur as far northward.

It is only necessary to add that all these species are inhabitants of tropical or warm waters, and the presence of a number of them so far northward was entirely unexpected; indeed, only a few can be regarded as regular summer inhabitants of the Massachusetts seas, and perhaps the majority of them must be looked upon as accidental or occasional visitors. The number of species found at Wood's Hole alone was one hundred and twenty, and the number of Massachusetts fishes, including fresh-water forms, is now increased to one hundred and seventy-nine. A striking contrast as to the extent of the fish fauna is exhibited between Wood's Hole and the present locality of the Fish Commission (Portland), at the latter only sixty-two species having yet been obtained, and among them there is not a single warm-water non-pelagic form. I am happy, however, to be able to announce the discovery of a number of specimens of the *Platessa glabra* of Storer, hitherto known (so far as can be ascertained) from a single specimen; that species proves to be a true *Pleuronectes*, the description and figure of Storer being erroneous.

SUGGESTION FOR FACILITATION OF MUSEUM ADMINISTRATION. By THEODORE GILL, of Washington, D. C.

ABSTRACT.

THIS paper detailed a system introduced into the Smithsonian Institution, in concert with Prof. Baird, for facilitating the arrangement of the collections. Catalogues of the families and subfamilies of the different classes, with numbers attached to the former and letters to the latter, were in the first place prepared, and these numbers and letters (for example 87 B,—87 indicating the number of the family and B the subfamily of that family) were attached to the bottles or specimens; these numbers and letters being fixed, and indicating exactly the groups, the most ignorant subordinates can be made use of for finding any specimens by simply giving the number and letter of those desired. The collection can also be revised by a subordinate unacquainted with science, and who is only required to see that all numbered and lettered alike are together. Other advantages were claimed. Catalogues with this object in view had already been published by the Smithsonian Institution for the classes of Mammals and Fishes, and those of Mollusks and others were being prepared.

THE QUARTZITE OF WILLIAMSTOWN AND VICINITY, AND THE STRUCTURE OF THE GRAYLOCK RANGE. By SANBORN TENNEY, of Williamstown, Mass.

THE quartzite of western Massachusetts, and the geological structure generally of the Graylock range and of the adjacent ranges of mountains, have long engaged the attention of some of the best geologists of the country. But I believe there is not yet a universal agreement as to the nature of the geological facts exhibited in this region, nor a universal agreement as to the significance of the facts observed. Therefore I feel that every new fact, that can be brought forward in regard to the geology of the region under consideration, is of interest and importance.

Living near the Graylock range and numerous outcrops of the

well known quartzite of the vicinity, I determined some time ago to examine carefully all this part of Massachusetts, and to make myself acquainted with all accessible geological facts revealed in this interesting region.

I have already carefully examined a considerable part of the most important portion of the ground, and some of the points of especial interest and importance I have examined several times. My examinations, however, are far from being completed, and therefore what I have to present now is merely a brief report of progress. But I beg to be permitted to say that my examinations have already been carried far enough to convince me that the quartzite of this part of the state of Massachusetts, and the structure of the Graylock range and of the adjacent mountains, are worthy of still further attention from our ablest geologists.

It has long been well known that the Taconic range is composed mainly of a finely laminated mica slate resembling a talcose slate; that Stone Hill, between the Taconic range and the Graylock range, is quartzite and black slates; and that between the Taconic range and Stone Hill there is a belt of limestone. It has also been long known that the Graylock range is composed of mica slate and limestone, the former making up the principal part of the entire range; and that between Stone Hill and the Graylock range, or rather on the eastern flank of Stone Hill, there is also a belt of limestone.

All of these rocks, as they occur in the region under consideration, have a northeasterly strike, and a steep easterly dip, the strike being north 10°—20° or more east, and the dip 20°—60° easterly.

It may also be stated here, as a fact which I am not aware has been stated before, that somewhat north of the latitude of Stone Hill, there is an additional outcrop of limestone half-way up the slope of the Taconic range.

In the relations of the slates of the Taconic range to the great limestone belt at its eastern base I find that there is no reasonable doubt that the slates dip under the limestone, although the absolute contact of the two kinds of rocks has not yet been found, owing to the loose materials which overlie them along their whole line of junction, as far as I have yet observed.

In examining the relations of the last named limestone belt to the quartzite of Stone Hill, I find evidence, which is almost conclusive,

that *the limestone dips under the quartzite*, instead of there being a fault between the limestone and the quartzite, as was held by the lamented Emmons, and as has been accepted by others. The evidence that the limestone on the west of Stone Hill dips under the quartzite of Stone Hill, is found mainly in the very close proximity of the two belts, and in the identity of their strike and dip. At the western base of Stone Hill, near a place well known as "Cold Spring," there is a large outcrop of the limestone which is distant from the quartzite but little more than the width of the public road and the stream that runs beside it; at one point about forty rods, more or less, northerly from Cold Spring the limestone appears nearer the quartzite by the whole width of the road and the stream, so that, although the line of junction cannot be seen, there is scarcely room for doubt that the limestone dips under the quartzite. Now going less than a quarter of a mile farther south, and ascending Stone Hill from the public highway on which Cold Spring is situated, we pass over a belt of limestone, the eastern portion of the belt just mentioned, and as we approach the crest of the hill we find the limestone and the quartzite in such relations that here again there can be no reasonable doubt that the former rock *dips under the latter*. It is true I have not found the line of junction of the two rocks, for no such line appears at the surface here. But the limestone outcrop and the heavy bedded quartzite have both the same strike and dip, and the strata in the two cases are *scarcely a rod apart*. I may add here, that at an early day I intend to cross-cut the rocks at this place, so that afterwards there never can be any question as to the relations which these two kinds of rocks sustain to each other at this locality.

Passing eastward from the outcrop of limestone just mentioned I find in the first place quartzite, then black slates, then quartzite again, these two kinds of rocks making up the main bulk of Stone Hill, as long ago pointed out by Emmons and others.

On the eastern slope of Stone Hill we find limestone again, and this we follow down nearly to Green River, a small stream which occupies the bottom of the valley between Stone Hill and the Graylock range. From this stream eastward to what would be popularly considered the *eastern* base of Graylock, that is, the immediate eastern base of the main portion of the mountain, though not the real base, *all the rocks have a steep easterly dip*, and they are all mica slate excepting a belt of limestone on the western slope

of Prospect, which, as may be inferred from the statement just made, dips under that mountain. But passing eastward from the immediate eastern base of Graylock, that is from the base immediately adjacent the main mass of the mountain, we soon find, after crossing a narrow belt covered with soil, grass and bushes, the mica slate dipping westward, that is towards or under the Graylock range; and passing eastward still, we soon find a broad belt of limestone also dipping westerly; and following this limestone still easterly we soon find it dipping easterly, and following it still farther toward the east, we find, before reaching the Pittsfield and North Adams railroad, that it dips westerly again. These facts point to the conclusion, long ago reached by Emmons, that the Graylock range is a synclinal, but not just such a synclinal as he has figured, since the main bulk of the whole range in the latitude of which I am speaking exhibits only steep easterly dips: so that the whole range has the appearance of a vast monoclinal. I may add here that I hope at an early day to publish a diagram showing the position of all these rocks as well as the position of the rocks from the Taconic range to the Hoosac range inclusive.

But one of the things which has specially attracted my attention in the study of the geology of this region is the relation of the quartzite to the limestone, when followed along the line of their strike. In studying the strata on the southerly slope of Stone Hill, within a hundred rods of the road leading from Williamstown to South Williamstown, I find the quartzite and limestone so closely associated with each other, as to indicate that the quartzite of Stone Hill gradually merges into limestone, and that therefore there is here really no distinct formation of quartzite, but a series of beds which are quartzite at Stone Hill and limestone to the southward, and probably to the northward also. And I am the more inclined to take this view from other similar facts which I will now present as I found them on the east side of the Graylock range, and which, so far as I am aware, are here brought forward for the first time. On the east side of the Graylock range, and near the "Notch" road, or "Bellows-pipe" road leading from the "Notch" to South Adams, and near the quarry where the limestone blocks were obtained for building bridges on the Troy and Boston railroad, I find the limestone on the west side of the road with a strike of north 20°—25° east, by the needle, and with a dip of 40° westerly. On the opposite or east

side of the road the same kind of limestone has a very steep easterly dip. Now following southward on the belt of limestone dipping easterly, I find the limestone suddenly replaced by *quartzite* as well defined as that at Stone Hill on the west of the Graylock range; and going still farther south a short distance, I find the quartzite and limestone very closely associated with each other, interstratified and passing into each other in many cases by easy gradations; but also in some cases the change occurs abruptly; in all cases, however, the two kinds of rocks maintain their conformability. The evidence here seems to be conclusive that the same series of beds are limestone at one place and quartzite at another, and this is perhaps the case with all the quartzite beds in this part of Massachusetts.

As regards the conclusion respecting the relation of the quartzite and limestone, so far as the passage of the one into the other along the line of their strike is concerned, I believe I am anticipated by Dana, in observations made in other places; but my conclusions are drawn from the data which I have now presented.

If the observations enumerated above are to be relied upon, they show that the limestone and quartzite are conformable at Stone Hill, and that the former dips under the latter; that the quartzite and limestone at Stone Hill, and at a locality near the eastern base of the Graylock range, pass into each other along the line of their strike; and that the Graylock range is a synclinal, as long ago shown by Emmons, but not exactly such a synclinal as he has figured, no westerly dips presenting themselves in the main mass of the mountain range, the synclinal being indicated only by westerly dips of the mica slate and limestone as exhibited between the main mass of the range and the Pittsfield and North Adams railroad. I repeat, *the main mass of the whole range appears like one vast monoclinal.*

I hope to present additional facts in regard to this range of mountains, and in regard to the Hoosac Mountain at an early day.

On the Cause of the Transient Fluctuations of Level in Lake Superior. By Chas. Whittlesey, of Cleveland, Ohio.

In this paper I shall confine myself to that class of fluctuations which are not only *transient*, but where there is a *wave-like* regularity of occurrence, and the height of the undulation is small. The *secular fluctuations*, extending through a series of years, no longer need discussion, as to their origin. It may be considered as settled that they are due to meteorological causes, extending through many years, giving rise to differences in the rainfall, and evaporation.

The *annual fluctuation* is subordinate to the secular, having the same origin, but the period is less, covering only the term of the seasons *within* each year. Neither do I mean to treat of those striking *irregular oscillations*, swashes or seiches, consisting of a bold crest moving rapidly along, often in quiet seas, which have been observed, from the time the Jesuit fathers made their first journeys along the shores of the Upper Lakes; nor to discuss the minute lunar tides, recently discovered through the observations of the United States Lake Survey; nor the long swells produced by distant storms. They are common to all lakes and seas, and the cause is shown, by the reports of the Lake Survey, to be variation of atmospheric pressure, and it is also universal. A fitful agitation of the waters, which I purpose noticing, will be found in all latitudes and climates, but it is more marked in the temperate and the frigid zones, because there, atmospheric changes are more frequent and more extreme.

The cause of the low *pendulum-like pulsations*, which Professor Mather observed at Copper Harbor, in July, 1847, and on which I made observations at Eagle River, in 1854 and 1856, reported in the Smithsonian Contributions for 1859, has not, so far as I know, been demonstrated.

These are no doubt common to all waters, but they are so slight that they are not generally noticed, and are more prominent on Lake Superior than on the Lower Lakes, for reasons that will appear to be good, provided my conclusions in regard to their origin are sound. My endeavor will be to bring them into the same category as the other fluctuations, although barometrical readings, as far as we have them, do not tally with such a conclusion. The period of the oscillation is too short, to produce an

appreciable change in the mercurial column. It requires some delicate mechanical contrivance to magnify the effect of slight barometrical movements, before the question can be settled by observation.

The readings of Professor Mather extended only through a part of a day, during which there was a storm in the vicinity. While the flux and reflux of the water was incessant, the movement of the mercury was regular, and such as was due to the storm. It indicated no atmospheric oscillations.

At Eagle River, twenty miles west of Copper Harbor, on the same coast, from the 25th to the 29th of June, 1854, the oscillations were continuous. Of six readings of my water gauge on the 29th, the average time between one rise and the next was (11) *eleven minutes*, the average height of the wave (3) *three inches and* (7-10) *seven-tenths*. No storm occurred in that vicinity during these days.

The readings which were made were intended to represent the *average* of the oscillations, which extended through a fortnight, not continuously, but without long interruptions.

On the 11th of October, my attention was arrested by the occurrence of a very regular series of oscillations, in calm water, with a stiff breeze off shore, that is, from the southeast.

The average of (8) eight readings, extended from 7.43 to 8.58 A.M., made at a dock in the open lake, in three feet of water, was for time from flood to flood (9) *nine minutes and* (4-10) *four-tenths;* for vertical range of flood (10) *ten inches and* (1-10) *one-tenth.* The undulations came in parallel with the shore and broke with a regular, but low ripple on the beach. They continued during the day, which was cloudy and rainy, without wind. In 1855 these movements were not noticed until the 20th of June, with calm and clear weather. They recurred on the 26th of June and on the 13th of July, continuing with little interruption for a week; weather cloudy, rainy and frequent thunder storms.

From the 24th to the 31st of July they occurred every day, the weather being quite the reverse of that in the middle of the month—warm, foggy and calm. In the month of August the oscillations were frequent, but with interruptions. On the morning of the 2d of August the average period was (12) *twelve minutes*, and in the evening of the 3d, it was (9) *nine and* (1-2) *one-half minutes*. During the 2d, the weather was calm, cloudy and sultry. On the 3d a thunder storm with wind.

In October, 1856, I was for the first time enabled to read the barometer and the pulsations at the same time. During one hour on the afternoon of the 21st they were very rapid, the mean of elapsed time being (3) *three minutes and* (1-10) *one-tenth*, with a northeasterly wind, a swell on the lake, and a driving rain. The barometer rose steadily from 29·440 to 29·520. During the succeeding four hours, or until 9 P. M., there was no cessation of the waves, and the barometer reached 29·603.

From 6.45 A. M. of the next day, until 9 P. M., there was only an occasional intermission, with very variable weather; barometer ranging from 29·485 to 29·600. On the third day, Oct. 23d, the movements were slight and irregular, barometer rising all day from 29·640 to 29·860, and light northerly winds. Average period of pulsations for one hour (7) *seven and* (4-10) *four-tenths minutes.*

The mean elevation of Lake Superior, above tide, is about six hundred and five feet. From the few barometrical readings hitherto made in reference to this class of movements, little can be inferred beyond the fact that the oscillations are more marked when the pressure is large.

Any agitation having its origin far out in the lake would approach the shore in waves nearly or quite parallel to it.

I have never seen an instance of perfect quiescence, on the waters of the North American lakes. On a shelving sandy beach there is always a slight wave-like ripple, even when the atmosphere appears to be perfectly tranquil, but there never can be a thoroughly quiet atmosphere, over a large area of water.

Until a better theory is found, I adopt that of atmospheric movement, as the cause of the undulations under consideration. There is a source of perpetual motion in the atmosphere, in the perpetual presence of *unequally heated areas*, to which I will soon make reference. Water is so sensitive to aërial currents that they cannot take place without producing an effect upon the equilibrium of its surface. I shall first show that all movements of flowing water are in a *wave-like* or undulatory form, and endeavor to deduce by analogy, that movements of the atmosphere take the *same form*, producing pulsations in the waters over which they move.

Pulsations in the Flow of Liquids.—Where a sheet of water flows over a dam, or a natural fall with a regular edge, it is incessantly changing. Its vibrations are sufficient to produce a mo-

notonous sound, that has in it something of musical harmony. Beneath the falling sheet, there is a constant flux and reflux of air, which, in large waterfalls like Niagara, gives rise to powerful gusts of wind. This is due to a constant *variation of pressure* within and without the sheet of falling water.

Jets and fountains, sustained by distant and quiet reservoirs, present a continual change, in the height of the discharge. The intervals between the lengthening and shortening of the columns vary with the size and form of the discharge pipe, and the head of the fountain.

One of the series of jets at Cleveland is a mile from the reservoir. In the centre is an upright pipe, throwing a jet about fifteen feet in height; with an orifice of about half an inch. It is surrounded by fifteen shorter ones, not quite half as long, which are curved outward; the orifice about one-fourth of an inch. In perfectly calm weather, all these discharges pulsate in perfect unison as to time; but not in the amount of rise and fall of the jets. Their period is from thirty-seven to forty in a minute.

When water is allowed to flow through a flexible tube, like a fireman's hose, or the ordinary rubber pipe, it is discharged, not with a steady stream, but in spirts that have regular intervals.

The molten material, coming from stack furnaces and cupolas, has the same undulatory or wave-like flow.

There is something analogous in the discharge of volcanoes and geysers. In flumes and in the narrow channels of rivers, as soon as the running water acquires velocity, the surface takes on the form of undulations lying across the current.

In the atmosphere, the effect of concussion is to produce consecutive waves, which spread from the point of agitation in a circular figure, and, by reaching the ear, produce sound.

The size, form and extent of this undulatory wave, depends upon the character of the agitation, or concussion. Those arising from lightning, or the discharge of fire-arms and artillery, have their pulsations sharp and violent. Musical instruments, such as trumpets, are made to produce an infinite variety of notes, by a slight variation of form in the instrument, which changes the form of the atmospheric wave, on its way to the drum of the ear. The human throat which is a flexible trumpet, closed at the orifice, is capable of more and finer modulations, than artificial ones, because it can produce undulations of infinitesimal dimensions. Stringed instru-

ments produce their various notes in the same way; and these waves of concussion have such relations to each other, that the tones they produce are musical harmonies. Light and heat are transmitted in the form of undulations. It is therefore reasonable to infer that movements of the atmosphere in general fall into the same category; and that this is a law in the motion of gases as well as fluids.

In the case of the atmosphere there is always present a cause or power which is too much overlooked, but which is perpetual and produces prodigious results, in the natural world. It is so simple and so quiet that it passes unnoticed. Wherever there are bodies *irregularly heated* in different parts, if they are fluid, there *must be motion.* In the waters of the ocean it gives rise to wide-spread currents, whose size, velocity and distance, are determined by the unequal distribution of heat over the earth. Aërial currents, both local and general, from the gentlest zephyr, through all grades of breezes, winds and storms, until a tornado is formed, are due to an unequally heated atmosphere.

Electrical action, and with it chemical action and magnetism, are brought into play in the same way. Germination and the growth of plants, the changes of the seasons and the annual progress of storms, are in the control of the same agent.

It is the foundation of the general circulation, which characterizes all departments of nature, and allows stagnation nowhere. The sun, in its daily action upon the earth, heats the soil, the waters and the air, irregularly. In its annual movement of declination, there is a change every day, in the effect of its rays upon the earth in every parallel of latitude.

On all shores there is a daily land and water breeze, arising from the unequal effect of solar heat for that day, upon the land and the water. As these movements are almost incessant, and the cause is ever present, if it is granted that they follow the general law of undulations, I think we have in them an explanation of those low but regular pulsations, which take place in the waters of all seas and lakes.

Descent of Rivers in the Mississippi Valley, Area of Drainage 1,000,000 Square Miles. By Chas. Whittlesey, of Cleveland, Ohio.

Of that part of North America east of the Rocky Mountains *four-fifths* lies below an elevation of 1,000 feet. Humboldt calculated the mean height of North America to be 748 feet, by which he meant, if a plane, or rather a spheroidal surface parallel with the earth's surface, should be passed at that height above the ocean, the parts above it, would fill up the spaces below.

Probably he would modify his estimate if he were now living and had access to the inter-oceanic railway sections, and would fix the plane of equalization somewhat higher. This would come, not so much by increasing the mass of the Rocky Mountains, as of the large elevated plateaus along their bases.

The proper establishment of such planes is a work beyond the resources of individuals. It requires the finances of governments, and the prolonged labor of their agents.

Profiles of surveys for railways present the same discrepancies as barometrical profiles, only in a less degree. The Coast Survey or the United States engineers, are the parties to establish such planes, in a manner to give confidence in the results.

Those which are here given provisionally are intended to illustrate some of the most striking topographical features of the United States. One of these is the large areas of low country. A plane at the elevation of 2,000 feet would have above it the mere caps of the Alleghanies, including the mountains of New York and New England. It would scarcely touch the Laurentian hills north of the St. Lawrence towards Hudson's bay, and would pass over that immense tract east of the Rocky Mountains, northward to the Arctic Ocean. This desolate region of rocks, scoured by the ancient continental glaciers, of drift gravel and bowlders and of countless lakes, filling cavities excavated during the ice era, is nearly equal to the United States in extent. Lake Winnipeg in Manitoba, which is as large as Lake Erie, lies only 820 feet above the ocean, Lake of the Woods 987 and Rainy Lake 1035. The low water-shed between the waters of Hudson's Bay, and those of the Atlantic where so many great rivers have their sources, will be noticed below.

For only a few of the streams in this valley, has the elevation of the channel or low water been taken. Such observations are

highly important for topographical purposes, because where there are no falls, chutes, or important rapids, the descent of the channel is approximately uniform. Between points only one or two hundred miles apart, it is nearly proportional to the distance, and the elevation of the adjacent country may be obtained with a barometer or by means of short side levels; using low water as a base. For instance, the Mississippi, at the mouth of the Ohio, is 324 feet above the Gulf. Midway it cannot be far from half that elevation, or 162 feet.

Mississippi River.

		Feet.
Mouth of the Ohio,	(Low water above gulf)	324
" " " Fevre River, Galena, Ill.	" " " "	503
" " " Des Moines, rapids 28 ft.	" " " "	
" " " Wisconsin, Prairie des Chiens,		518
" " " Black River,		594
Lake Pepin,		630
Mouth of the St. Croix River,		645
" " " St. Peter's " Mendota,		692
Head of Falls of St. Anthony,		777
Mouth of the Crow Wing River (chutes and falls below at St. Cloud),		1130
" " " Sandy Lake Outlet,		1253
Pokegema Falls, at base, fall 10½ ft.,		1340
Cass or Red Cedar Lake,		1400
Itasca Lake (Schoolcraft's source),		1532
Turtle Lake (Beltrami's "),		1413
Leech Lake (greatest flow of water),		1380

Missouri River.

The elevations along this river are not always distinguishable from those of the towns on the bluffs:—

Fort Leavenworth (adjacent hills 912) river,	750
Omaha (river bluffs),	1217
Fort Pierce,	1509
Red Cedar Islands, latitude 43° N. (bluffs),	2033
Fort Clarke,	1827
" Berthold,	1873
" Union, mouth of Yellowstone River,	1879
Mouth of Milk River (water level),	2010
Fort Benton,	2663

Ohio River.

	Feet.
Mouth at Cairo (low water),	324
Cincinnati (falls at Louisville 27 ft.),	429
Portsmouth, Ohio,	469
Marietta (three ft. below Lake Erie),	562
Pittsburgh, Pa.,	704
Mouth of French Creek, Franklin, Pa.,	908
Olean, N. York,	1280
Chautauque Lake, N. Y.,	1291

Waters of the Tennessee River.

Tuscumbia, Alabama,	600
Chattanooga, Tennessee,	675
London "	737
Knoxville " (railroad depot 898) river level,	816
Sources near Bristol, state line of Virginia,	1678
Little Tennessee, state line, at a gap in the Unikoi Mountains, high water,	1114
Tellico River at old furnace,	1149

Plane of One Thousand Feet Elevation.

The intersecting line of a plane, one thousand feet above tide, commences at the southwest on the Rio Grande near Ceralvo (1066), proceeds in a curve along the base of the rolling or hill country, turning up the Colorado, thence to the neighborhood of Fort Worth on the Trinity (1100) and by another curvature to the south and east around into the valley of the Red River. It extends up this stream, into the Indian country a distance not yet determined; doubling back on the north side, over the high land, to the valley of the Arkansas. This river comes out of the country of hill and mountain, in the neighborhood of Little Rock, whence the plane of one thousand feet cuts the surface along the foot of the Ozarks, in a northeasterly direction to the heads of the St. Francis. Bending abruptly to the west, across southwestern Missouri, the line is quite irregular and impossible of determination in the present state of information, but strikes the Kansas River near the mouth of the Kaw. From thence it will cross the Missouri River, not far below Omaha, turning back into northwestern Missouri and leaving most of Iowa beneath it, and will take a course nearly north to Lac qui Parle, and Big Stone Lake in Minnesota. Here it

sweeps away to the northwest, down the west side of Red River to the waters of Mouse River, and the Saskatchewan in Canada.

On the eastern side of the Mississippi it can be better defined. Beginning in the hill country at the terminus of the Blue Ridge, in Georgia, and of the Cumberland in Alabama, the plane leaves below it nearly all of the valley of the Chattahoochee and its branches, sometimes passing up these valleys beyond the Chattanooga and Atlanta railway. Coming around the buttresses of the Cumberlands near Tuscumbia, a narrow tongue is thrust up the Tennessee valley, beyond Knoxville and also up the Sequatchie valley. Passing thence westward around the most westerly flank of the Cumberlands, between Bridgeport and Huntsville, it turns sharp to the north in the valley of Elk Creek, following the base of the mountains northeasterly to the Cumberland River, above Monticello in Kentucky. It cuts near the tops of the hills around Lexington, Frankfort, Covington and the Highlands in Ohio. In Indiana and Illinois, probably, there is no point rising to an elevation of one thousand feet.

In West Virginia, there are many knolls, which are below the base of the mountains, but rise above the level of one thousand feet. It passes about three hundred feet up the side of Cotton mountain at the Falls of Kanawha, and the same on the hills around Pittsburgh.

Up the Alleghany, it intersects the river hills at the mouth of French Creek one hundred feet above low water. The passes or lowest water crests in Ohio lie nearly in it, all of them showing the abrasion of the ice period. There are very few summits in this state that rise two hundred feet above and very few that lie below it. As already stated, the water gap between the St. Mary's and the Great Miami is nine hundred and forty-two; Tymochtee summit level eight hundred and ninety-eight; Black River, Medina Co., nine hundred and one; Portage summit nine hundred and fifty-eight; Mahoning and Grand Rivers, Trumbull Co., nine hundred and eight, above sea level.

It passes four hundred and thirty-five feet above the surface of Lake Erie, intersecting the slopes of its south shore, near their tops, leaving below it a large space in New York and on the north of the lakes in Canada.

The lowest water gaps between the interior lakes of New York and the waters of the Susquehanna are close under this plane.

In the lower peninsula of Michigan there are very few points that reach up to it, the highest pinnacle of Mackinaw Island being two hundred feet below. In the upper peninsula a large part of the country lies above the line of one thousand feet, though it seldom rises to that of two thousand.

The sand dunes east of Grand Island and the surface of the country east of the Chocolate River lie in this imaginary plane, which crosses the Menominee River, near the Twin Falls into Wisconsin, and thence westerly across the Wolf River, near Lake Poteau and the Wisconsin near Stevens Point, to the Bluffs of the Mississippi at Lake Pepin. Here it deflects north up the valley of the St. Croix, to the heads of its northern branches and those of the Brulè. From the Brulè portage the line passes west through Fortuna to St. Cloud, and to the portage of Lac qui Parle, where it comes in contact with the one already described, coming up on the west side of the Mississippi valley.

North of this it separates, bending northeasterly down Red River valley and across to a point on Rainy Lake River, between Lake of the Woods and Rainy Lake. From here its course around the Basin of Hudson's Bay, through that rough but low region of bare rocks and pure water, cannot as yet be defined.

On the Origin of Mountain Chains. By Chas. Whittlesey, of Cleveland, Ohio.

The first result of the act of creation, as applicable to matter, must have been the production of *simple substances*, such as metals, the non-metallic solids like carbon, phosphorus and sulphur; and of gases, such as oxygen, chlorine, hydrogen and nitrogen.

To them should be added the imponderables; light, heat, electricity and magnetism.

As the imponderables produce chemical action in material substances, and motion, which produces momentum, they must be regarded as material. We are unable to conceive of a thing which is neither matter, nor spirit. It is too much for the human mind to decide, certainly in the present state of knowledge, the order in

which the creation of material substances took place; but there must have been a succession, and there must have been in some cases, long intervals between the acts of creation. Until oxygen was present there could be no oxides, or water. Sulphides and chlorides are not possible, until there is sulphur and chlorine.

According to the theory of La Place, which has received the general assent of philosophers, the solar system must have been at some period of its existence in a nebulous condition, analogous to vapor; occupying a spherical space whose radius was equal to that of the orbit of the farthest planet, and having a motion of revolution.

Such a condition is incompatible with the existence of binary compounds, such as oxides, earths, alkalies, water, the atmosphere and acids. It might occur with pure metals, or with metals and hydrogen, or such gases as have no chemical affinity for metals.

The consequences that follow from this affinity are no part of creation, but the results of qualities impressed upon matter; which go by the name of "secondary causes," or *natural laws.* They had much to do, however, with the structure of our globe; but must not be confounded with the creative acts.

Hydrogen and nitrogen might be introduced into this mass of metals in a state of vapor, with comparatively small results, but those which must follow the appearance of oxygen were prodigious.

Between 30 and 40 per cent. of the crust of the earth, including water, is oxygen in a state of chemical union. The igneous rocks are molten oxides. The sedimentary strata are oxides that have been in suspension, or salts that have been in solution, in which oxygen is the leading component.

Imagine all the metals in a state of vapor, which requires a high degree of heat, the whole in a shape of a rolling sphere, surrounded by an atmosphere of oxygen. Potassium and sodium, iron and calcium, would combine with it so rapidly that most intense heat would result; and there would be a general combustion. Other metals combine less rapidly, but in time a large part of the free oxygen present must assume a solid state.

Chemical action, which includes combustion, is probably due to electrical action, which is always excited in bodies that are unequally heated. The process of general oxidation might produce the requisite electrical conditions to form water, which must have

preceded the deposition of the sedimentary rocks, and the presence of vegetable or animal life.

A world of inanimate matter might fill its place in the solar system, but could fill no place in a moral or intellectual system, of which personal sentience and happiness form a leading part.

The presence of oxygen brought into play the acid forming affinities, giving rise to the ubiquitous carbonic, sulphuric hydrochloric and nitric acids; which in turn seized upon the oxides, alkalies and earth, forming a multitude of *quaternary* compounds.

As nitrogen is lacking in affinity for metals, most of it remained free and mingled with the surplus oxygen, constituting the atmosphere. All these processes are secondary, and the result of causes that are natural and not beyond our comprehension; but all of them must have occurred before there were rocky strata or mountains.

Mountain chains could not be elevated until the solid crust of the earth was formed.

Nearly all great mountain ranges are composed of sedimentary strata carrying marine fossils, which proves that they were once beneath the ocean. These rocks are quite different from the molten material, of which the interior of the earth is composed.

This fluid mass, arranging itself around the centre of gravity in a spheroidal form, should be in a quiescent, and not an aggressive state. There is nothing in a liquid body of this character calculated to produce a rupture of the solid crust which rests upon it.

How then are mountain chains raised many thousand feet above the mean surface of the earth, on long lines of fracture? Volcanoes, or the forces that produce volcanoes, and earthquakes, are not adequate to such results. These have been observed during the historical period, and are not known to have acted along fissures to elevate chains of mountains, but only at points, to build up cones with mud, scoria, and lava, thrown out of a circular vent.

These self-constituted escape pipes have been well compared to safety valves. Volcanic discharges are local, and are due to the pressure of confined gases, and of steam, acting on the fluid mass beneath. There are about three hundred of them, active and latent, most of which are located in the sea, producing islands of various sizes. Earthquakes are connected with these eruptions, and with the local rise and sinking of the land, but not with long fissures and uplifts.

The rise of mountain ranges was generally gradual, and not spasmodic; and must be due to some cause that has pervaded this planet, operating more energetically, however, while the sedimentary rocks were being deposited. Very few were uplifted prior to the era of the lower silurian formations.

Those of the laurentian age, like the Adirondacks of New York, are not numerous nor prominent. The Cumberlands and most of the Alleghany range rose since the deposit of the coal. A large part of the Rocky Mountains, and the other Pacific ranges, are cretaceous and tertiary.

The most satisfactory theory of elevation is that of lateral compression, due to the contraction of the solid surface of the globe, by radiation of its heat. Such a contraction would produce wrinkles and corrugations along long lines, nearly straight, which could not be done by an explosive force.

Mountain knots, like the Adirondacks, which are as a group nearly circular, might be produced by such forces acting in succession; consequently the pre-silurian mountains partake more of this character, than those of subsequent date.

The brothers Rodgers while engaged upon the surveys of Pennsylvania and Virginia, and Prof. Leslie, since their day, have given special attention to strata folded on each other throughout the Appalachians. In places they are tilted over so as to be reversed in their geological order. The tops of the ridges are nearly straight, overlooking narrow valleys, also straight, like Laurel Hill in Pennsylvania and Waldroun's ridge in Tennessee, the folds being numerous, and of nearly equal height. By pushing any flexible plane together from the edges, under a weight, precisely such parallel wrinkles will be produced. To treat of the condition of the earth during the sedimentary era, which gave rise to such a compressing force, is not a part of my present programme, which is simply to call attention to the inadequacy of earthquake action to form mountain ranges.

On the Species of the Genus Micropterus (Lac.) or Grystes (Auct.). By Theodore Gill, of Washington, D. C.

The best excuse for the presentation of so technical an article to the Association will be found in the popular interest in the species of this genus, celebrated in different parts of the United States under the name of black bass, but also called, in the southern states, trout, salmon, chub, etc. The nomenclature of the species has become involved in much doubt, and, if we may judge from the literature and the distinctions insisted on by Prof. Agassiz and others,* at least four or five species are supposed to exist in our waters; but it is evident from a perusal of the descriptions that the distinctions hitherto made are of very doubtful value.

Having been requested by the United States Commissioner of Fish and Fisheries (Prof. S. F. Baird) to determine the number of species represented in the fresh waters of the United States, and the earliest names respectively assigned to them, all the specimens in the collections of the Smithsonian Institution were examined,

* In the nominal (1) "*Grystes fasciatus* Agass.," it is said, "the *scales are* a little *smaller*, but of the same form as in (2) *G. salmoides;* the radiating striæ are perhaps less marked. They cover the opercular apparatus and the *cheeks*, but at this latter place *their* [*the scales'*] *smaller size is quite remarkable;* this latter character is very striking when we compare both species."—Agass., Lake Superior, p. 296.—The italicized portion (not italicized in original) indicates that the *G. salmoides* Agass. was a large-mouthed form. (3) "*Huro nigricans* Cuv. is another species of the lower Canadian lakes, which occurs also in Lake Champlain . . . . I shall therefore call it in future *Grystes nigricans*. . . . . Dr. DeKay describes it as *Centrarchus fasciatus*, although he copies also Cuvier's description and figure of *Huro nigricans*, but without perceiving their identity." Agass., Lake Superior, p. 297.—*Huro nigricans* Cuv. and Val. and *Centrarchus fasciatus* DeKay are unquestionably distinct, the former being the large-mouthed species, and the latter the small-mouthed one. It is probable, however (thus giving him the benefit of the doubt), that Prof. Agassiz based his idea of the species on the large-mouthed form.

"The species of this group [*Grystes* Cuv.] are indeed very difficult to characterize. They differ chiefly in the relative size of their scales, the presence or absence of teeth on the tongue, ... etc. There are besides marked differences between the young and adults. These circumstances render it impossible to characterize any one species without comparative descriptions and figures. (4) The species from Huntsville [Ala.] . . . differs equally from [*G. fasciatus* Agass. and *G.* "*salmoneus*" Agass.]. I call this species provisionally *Grystes nobilis* Agass." Am. Jour. Sci. and Arts (2), xvii, p. 297, 298, 1854.

Prof. Agassiz thus recognized four species (besides indeterminate ones), viz:—

1. *G. fasciatus* Agass. = *M. salmoides*.
2. *G. salmoides* Agass. (not Cuv. and Val. nor *G. salmoneus* Agass., 1854) = *M. nigricans*.
3. *G. nigricans* Agass. = *M. nigricans?*
4. *G. nobilis* Agass. = *M. nigricans*.

Judging by the comparisons, Prof. Agassiz had in view, in 1854, in the "*G. salmoneus*," the true *M. salmoides*.

Baird and Girard added to these species, also in 1854, (5) their *G. nuecensis* = (*M. nigricans*).

as well as a large series from many other localities kindly transmitted for that purpose by the Museum of Comparative Zoölogy (Prof. Agassiz, Director). Study and comparison of those specimens clearly demonstrated that two perfectly distinct types of the genus were represented in most of the waters of the cismontane (east of the Rocky Mountain) slope of the United States, except those of the New England states and the Atlantic seaboard of the middle states. In limitation of this general statement it need only at present be remarked that but one of those types, the small-mouthed, appears to have been an original inhabitant of the hydrographic basin of the Ohio River.

In order to obtain as clear and unprejudiced ideas as possible respecting the species, the specimens from all the localities were in the first place examined without reference to their names but only with the view to ascertain their relations to each other. This examination confirmed the previous experience of the author for a more limited range, and led to the combination of all into the two groups just referred to: between these many differences existed, but none were discovered which permitted further definite subdivision. The differences thus ascertained may be tabulated as follows:

Contrasted Differential Characteristics.

Small-mouthed.	Large-mouthed.
Scales of trunk	
Small (*e. g. lat. line*, 72–75; between lateral line, and back, 11 rows).	Moderate (*e. g. lat. line*, 65–70; between lateral line and back, 7½ or 8 rows).
Scales on nape and breast	
Much smaller than those of sides.	Scarcely (on nape), or not much (on breast) smaller than those of sides.
Scales of cheeks	
Minute (*e. g.*, between orbit and preoperculum, about 17 rows in an oblique line and about 9 in a horizontal one).	Moderately small (*e. g.*, between orbit and preoperculum, about 10 rows in an oblique line and about 5–6 in a horizontal one).
Scales of interoperculum uniserial	
Covering only about half the width of the bone.	Covering the entire width of the bone.

Scales of preopercular limb	
None.	Developed in an imperfect row (*e. g.*, 3–5 in number).
Scales on dorsal	
Developed as a deep sheath (involving last spine) of small scales differentiated from those on the back, and with series advancing high up the membrane behind each ray (except last two or three).	Developed as a low (obsolete) shallow sheath, and with series ascending comparatively little on membrane behind the rays (none behind last five or six).
Scales on anal	
Ascending high behind each ray.	None (or very few).
Mouth	
Moderate.	Large.
Supramaxillary	
Ending considerably in front of hinder margin of orbit (about under hinder border of pupil).	Extending considerably behind the posterior margin of orbit.
Rays	
Dorsal, articulated, 13. Anal III, 10–11. Pectoral, 1·16–1·17.	Dorsal, articulated, 12 (I. 11). Anal III, 10. Pectoral, 1·14 (1·13).
Dorsal fin in front of soft portion	
Little depressed, the ninth spine being only about a half shorter than the longest (3, 4, 5) and a fourth shorter than the tenth.	Much depressed, the ninth spine being only about a fourth as long as the longest and half as long as the tenth.

Thus numerous and well marked are the differences between the two groups; within the limits of neither of these groups were found differences in the slightest degree comparable with them or that suggested the differentiation of the forms into distinctly marked subordinate types: in other words, no differences were found of specific value, and, although a renewed examination may possibly result in the discovery of some, their value must be very slight in comparison with those distinguishing the two groups indicated: these groups may therefore be considered as specific. The question now arises, What are the names to which they are respectively entitled? In order to ascertain this, it is advisable to enter quite fully into the very complicated history of the genus.

Bearing strictly in mind the differential features of the two species, we may now proceed to an analysis of the successive descriptions of forms of the genus and endeavor to refer them to their respective types.

The first scientific allusions to any species of the genus are found in the great work on fishes by Comte de Lacepède.*

In 1800, in the third volume (pp. 716, 717), Lacepède introduced into his system, under the name *Labrus salmoides*, a species based on a description and figure sent him by Bosc from South Carolina, which, according to Cuvier and Valenciennes, relate to the small-mouthed type.

In 1801, in the fourth volume (p. 325), Lacepède described, as a new generic type, named *Micropterus Dolomieu*,† a fish concerning which no particulars were given as to habitat or station and which could not have been positively identified from the description: the original specimen having been preserved, however, Cuvier and Valenciennes ascertained that it belonged to the genus *Grystes* and was in fact identical with the species described by Lacepède from the notes and figures of Bosc as *Labrus salmoides*.

In 1817, C. S. Rafinesque‡ described a form of the same genus under the name *Bodianus achigan* which evidently belonged to the small-mouthed type: while most of the characters noted are common to all the species (or erroneous), the number of rays (D. IX I, 14 §; A. III, 11 ‖) and the absence of scales on the preoperculum (gill covers "all scaly except the second") indicate the pertinence of the species to the group in question: the number

* LACEPÈDE (Bernard Germain Étienne de la Ville-sur-Illon, Comte de). Histoire Naturelle des Poissons, ... Paris. . . . . [1798—1803, 4to 5 v].

† "12le genre. Les Microptères.

"Un ou plusieurs aiguillons, et point de dentelure aux opercules; un barbillon, ou point de barbillon aux mâchoires; deux nageoires dorsales; la seconde très-basse, très-courte, et comprenant au plus cinq rayons.

"Espèce. Le Microptère Dolomieu.

"*Caractères.* Dix rayons aiguillonnés et sept rayons articulés à la première nageoire du dos; quatre rayons à la seconde; deux rayons aiguillonnés et onze rayons articulés à la nageoire de l'anus; la caudale en croissant; un ou deux aiguillons à la seconde pièce de chaque opercule." [Br. 5; p. 16; v. i, 5; c. 17].

‡ RAFINESQUE-SCHMALTZ (Constantine Samuel). Museum of Natural Sciences. By C. S. Rafinesque, Esq. First Decade of New North American Fishes. <The American Monthly Magazine and Critical Review. Vol. ii, New York, . . . 1817 (pp. 120, 121).

§ "The dorsal depressed in the middle and with twenty-five rays, whereof ten are spinescent." It is assumed that the last or double branched ray is counted as two.

‖ "Anal fin with fifteen rays whereof three are spinescent and short." The last ray was also in this case probably counted as two.

of rays (15) attributed to the pectoral does not confirm this identification, but the number (admitting even the accuracy—very doubtful—in the case of the very careless observer) is within the range of variation of the type. The exact locality from which Rafinesque derived his types was not specified, but they were probably observed by him at Lake Champlain, where he had shortly before collected (See Am. Month. Mag. and Crit. Rev., ii, p. 202, Jan., 1818).

In 1820, the same naturalist described, in his way, various specimens which appear, almost without doubt, to be referrible to the same type. These descriptions appeared originally in the "Western Review and Miscellaneous Magazine," published at Lexington, Kentucky, and were reprinted (from the same types) for the "Ichthyologia Ohiensis."* No less than six generic and subgeneric names appear to have been based primarily on a species of this type and as many as seven nominal species, viz:—

GENERA AND SUBGENERA.

1. Calliurus (n. g.).
2. Lepomis (n. g.).
   Aplites (n. s. g.).
   Nemocampsis (n. s. g. prov.).
   Dioplites (n. s. g.).
3. [Etheostoma].
   Aplesion (n. s. g.).

SPECIES.

1. Calliurus punctulatus.
2. Lepomis pallida (s. g. Aplites).
3. Lepomis trifasciata (s. g. Aplites).
4. Lepomis flexuolaris (s. g. Aplites, or n. s. g. Nemocampsis).
5. Lepomis salmonea (s. g. Dioplites).
6. Lepomis notata (s. g. Dioplites).
7. Etheostoma calliura (s. g. Aplesion).

Of these, it need here only be in general remarked that the differential characters employed result (1) partly from erroneous observation and (2) partly from erroneous assumptions:—that is, because the author had not signalized certain characters in specimens previously examined, but which were noticed in others examined

*Ichthyologia Ohiensis, or Natural History of the Fishes inhabiting the River Ohio and its tributary streams, . . . Lexington, Kentucky; printed for the author by W. G. Hunt. (Price one dollar). 1820. (pp. 26—36). Reprinted (with separate pagination and adjustment for form) from the Western Review and Miscellaneous Magazine, Lexington, Ky. Vols. i, ii, and iii (Dec. 1819 to Nov. 1820).

later, he assumed that they did not exist in the former and therefore the two differed. Inasmuch, however, (1) as all the descriptions cited, best (and decidedly so) agree with species of the genus *Micropterus*, and (2) as, in those respects in which they differ, they equally deviate from all known forms in the waters from which they were obtained, and (3) as it is in the highest degree improbable that forms better agreeing with them have been overlooked, the names in question are all relegated to the synonymy of *Micropterus*. Within that genus in almost every case some specification (chiefly as to the number of rays) indicates that the several descriptions were based on individuals of the small-mouthed type. This probability is greatly enhanced by the fact that (so far as known or recorded) the small-mouthed species was the only one known from the localities where Rafinesque observed.

The description of *Calliurus punctulatus*, however, it has been thought by Prof. Agassiz, was based on a form of the sunfish type with large mouth. But such could not have been the case as is quite evident from the armature of the operculum ("opercule with an *acute* and membranaceous appendage, before which stands a flat *spine*"), the contour of the dorsal ("*depressed* in the middle"), and above all the number of the rays of that fin ("dorsal fin yellow with *twenty-four* rays, of which ten are spiny"); in all these respects (as well as others), the description is inapplicable to a Pomotid and only applicable to a *Micropterus*.

A couple of years later (in 1822), a much more reliable naturalist* published descriptions of five supposed new species of the genus Cichla of Bloch (as supposed to have been adopted by Cuvier). All except one (*C. ænea* = *Ambloplites rupestris*) really belong to the genus *Micropterus*, and all the northern forms (*C. fasciata*, *C. ohiensis*, *C. minima*), as is evident from the allusions to the number of rays, squamation, or size of mouth, belong to the small-mouthed type, while the description of the Floridian species (*C. floridana*) is as applicable to the same as to the large-mouthed type. The descriptions are not sufficiently contrasted and are too general and therefore vague; nor, on comparison with specimens, are the differences suggested by the mention of characters in one case and their neglect in another apparent. As no reference was made

*LE SUEUR (Charles A. . . .). Descriptions of the [*sic*] five new species of the genus Cichla of Cuvier. By C. A. Le Sueur. Read June 11, 1822. <Journal of the Academy of Natural Sciences of Philadelphia. Vol. ii, Part i. Philadelphia. . . . 1821. [pp 214—221].

to the forms of the same type previously described, although the author was doubtless acquainted with Rafinesque's memoir, it is presumable that the neglect was intentional (and doubtless provoked by the character of that author's work) and not without strong suspicion that the species named had already, perhaps, received designations, but with unrecognizable descriptions.

In the great "Histoire Naturelle des Poissons,"* Cuvier and Valenciennes described the two species of the genus, but, deceived by the state of their specimens—in one case at least (*Huro nigricans*), completely failed to recognize the relations of the two. (1) In 1828 (tome second, pp. 124–126) they described the large mouthed species as a new generic type (under the name *Huro nigricans*), but, misled by an injury to the spinous portion of the dorsal fin (and apparently the loss of the seventh spine), they ranked it in their group of Percoids with two dorsal fins, attributing to it a first dorsal with six spines, and a second with two spines in front (instead of ten dorsal spines). (2) In the following year (1829) and volume (tome troisième, pp. 54—58), they described the small-mouthed species, identifying it with the *Labrus salmoides* of Lacepède, and forming for it (and at the same time associating with it an Australian fish) the genus Grystes: this was referred to the section of Percoids with a single dorsal fin and placed after *Centropristes* and before *Rhypticus*. The descriptions of both species (after making allowance for the error induced by the state of the dorsal in *Huro*) were quite good, and, especially in the case of *Grystes salmoides*, much better than any subsequently published, and they can consequently be identified without difficulty.

Subsequently, Dr. DeKay, in his "Zoology of New York,"† reproduced the figures and (in a modified form) the descriptions of the two species from Cuvier and Valenciennes' work, but, failing to identify them, redescribed and refigured one of them (*Grystes salmoides*) under two names (*Centrarchus fasciatus* = *Cichla fasciata*

*CUVIER (Georges Chrétien Leopold Dagobert *baron*) and Achille VALENCIENNES. Histoire Naturelle des Poissons, ... Paris, ... 1828—1849. [t. ii, 1828, pp. 124—126; t. iii, 1829, pp. 54—58].

†DEKAY (James E...). Zoology of New York, or the New York Fauna; comprising detailed descriptions of all the animals hitherto observed within the State of New York, with brief notices of those occasionally found near its borders, and accompanied by appropriate illustrations. By James E. DeKay. Part IV. Fishes.—Albany; printed by W. & A. White & J. Visscher. 1842. [4to, xiv [1, errata], 415 pp.; atlas, 1 p. l., 79 p. 1].

Les. and *Centrarchus obscurus* DeKay, n. sp.). Of course all were adopted by Dr. Storer in his "Synopsis of the Fishes of North America."* In those works, therefore, the species stand under three generic and four specific names.

In 1850, Prof. Agassiz, in his "Lake Superior,"† decidedly advanced beyond his predecessors, (1) recognizing, for the first time, the generic identity of the forms described by LeSueur, Cuvier and Valenciennes, and DeKay, (2) retaining for the genus thus enlarged the name Grystes, and (3) recognizing two species as inhabitants of the north; he was, however, less fortunate in his appreciation of their specific relations, (1) his *Grystes fasciatus* being the small-mouthed form, (2) his "*Grystes salmoneus*" (as is evident from the contrasted characters noticed in his comparison of *G. fasciatus* with it) being the large-mouthed southern form, and (3) his *Grystes nigricans* being differentiated without statement of reasons and the *Centrarchus fasciatus* of DeKay identified with it.

At a later period (1854), Prof. Agassiz distinguished specimens of the genus obtained from Huntsville,‡ Alabama, as *Grystes nobilis*, which evidently belongs to the large-mouthed type; the brief notice is only comparative, contrasted with the small-mouthed type, and contains no specific peculiarities.

In the same year and month (March, 1854), Messrs. Baird and Girard § described specimens of the same type from the "Rio Frio and Rio Nueces, Texas," under the name *Grystes nuecensis*. This form was subsequently described in greater detail and illustrated by Dr. Charles Girard, in the Report on the Mexican Boundary Survey.

*STORER (David Humphreys). A Synopsis of the Fishes of North America. . . . <Memoirs of the American Academy of Arts and Sciences. New series. Vol. ii (Cambridge, 1846), pp. 253—550.

———A Synopsis of the Fishes of North America. . . . Cambridge: Metcalf and Company, printers to the university. 1846. [4to, 1 p. l. (=title), 298 pp.]

† AGASSIZ (Louis). Lake Superior; its Physical Character, Vegetation, and Animals, compared with those of other and similar regions. . . . Boston; . . . 1850. (p. 295).

‡ AGASSIZ (Louis). Notice of a collection of Fishes from the southern bend of the Tennessee river, Alabama. . . <The American Journal of Science and Arts, second series. Vol. xvii. . . . 1854. [pp. 297—308; 353—365=Grystes, pp. 297, 298.]

§ BAIRD (Spencer Fullerton) and Charles GIRARD. Descriptions of new species of Fishes collected in Texas, New Mexico and Sonora, by Mr. John H. Clark, on the U. S. and Mexican Boundary Survey, and in Texas by Capt. Stewart Van Vliet, U. S. A. . . <Proceedings of the Academy of Natural Sciences of Philadelphia. Vol. vii, 1854, 1855. [pp. 24—29; Grystes, p. 25].

In 1857, Dr. Theodatus Garlick* of Cleveland, Ohio, in a treatise on the propagation of fish, described and published rough woodcut figures of the two forms of the genus: (1) the small-mouthed species under the name "*Grystes nigricans;* or black bass;" (2) the other, as a new species designated "*Grystes megastoma;* or, large-mouth black bass."† The species are quite well distinguished by the size of the mouth and the comparative size of the scales: his *Grystes nigricans* is, however, not the true *Grystes nigricans* (*Huro nigricans* Cuv. & Val.), as that name really belongs to his *Grystes megastoma.*

In 1859, Dr. Günther‡ described specimens of the small-mouthed species under the name *Grystes salmoides*, and first restricted the genus to that species (having removed the Australian species as the type of a new genus—*Oligorus*). Having overlooked the rectifications by Prof. Agassiz, he continued the errors of his predecessors, admitting as nominal species (1) *Huro nigricans*, (2) *Centrarchus fasciatus*, and (3) *Centrarchus obscurus*, and also the same species as doubtful forms (in foot-notes) of *Grystes*, i. e. *G. nuecensis* and *G. fasciatus.*‡

For the present, the notices and descriptions of the several forms of the genus by other authors may be passed over in silence, as they do not involve any questions of nomenclature. It may be added, however, (1) that the author had long recognized the existence and differences of the two species of the genus, one under the name *Micropterus achigan:* the other as *Micropterus nigricans*, and (2) that Prof. Cope, under the names *Micropterus fasciatus* (which he attributed to the present author through some misapprehension) and *Micropterus nigricans* has signalized the same species from widely distant regions (*e. g.*, Michigan, Virginia, North Carolina), and has evidently understood their relations.

Analysis of all the published descriptions and comparison with the fishes themselves led to the following conclusions:

*GARLICK (Theodatus). A Treatise on the Artificial Propagation of certain kinds of Fish with the descriptions of such kinds as are the most suitable for pisciculture, ... Cleveland, Tho. Brown, publisher, Ohio Farmer office, 1857. [12mo, 142 pp. Grystes, pp. 105—110.]

† "This fish has been identified with the common black bass (*Grystes fasciatus*), but is by no means the same fish, differing in many respects, both in its habits and physical structure, and has not been described in any work on American fishes, so far as I can learn" (*op. cit.* p. 108).

‡ GÜNTHER (Albert). Catalogue of the Acanthopterygian Fishes in the Collection of the British Museum, ... Vol. i, .. , London; ... , 1859 [pp. 252—255].

SECTION 1.—MORPHOLOGICAL.

After an examination and comparison with each other of specimens from the great lakes (Champlain to Michigan), the states of New York, Pennsylvania, Ohio, Michigan, Illinois, Iowa, Kentucky, Missouri, Tennessee, Alabama, Texas, Wisconsin, West Virginia, Virginia, North and South Carolina, and Georgia, no differences could be found much if any greater than such as could be detected among numerous individuals from any given locality. There are differences resulting from age and condition; the fins may be (slightly) more or less developed, and the colors may be more or less intense, but no deviations have been found, from the ordinary standard, of such a character as at all to compare, for example, with the differences between the large-mouthed and small-mouthed forms, or to indicate that there are any specific differences among the small-mouthed or large-mouthed forms. The natural course, then, appears to be to recognize only the two forms whose differences are so obvious as species, and—at least till differences may be detected of which none have yet been found—to consider all the other forms, and from all localities, however distant they may be, as representatives or varieties of those species.

SECTION 2.—NOMENCLATURE.

A critical analysis of the numerous notices and descriptions of the forms of the genus indicates that the differences between the respective species have been very imperfectly apprehended, and mostly confined to the size of the mouth and in vague terms to the size (comparatively large or small) of the scales: most of the other differences signalized are either non-existent or individual and dependent on the condition of the specimens. The charge of vagueness and insufficiency of diagnosis is especially applicable to the first descriptions of species of the genus; guided, however, by a knowledge of the geographical distribution of the genus and hints furnished by the radial formulas, etc., it may be safely concluded, (1) that most of the names referred to in the historical introduction may be relegated to the synonymy of the small-mouthed species; (2) that the first name applied to that species was *Labrus salmoides;* (3) that only the names *Huro nigricans*, (and most of its derivatives), *Grystes megastoma*, *Grystes nobilior*, and *Dioplites nuecensis* belong to the large-mouthed species; (4)

that the name *nigricans* is therefore the first specific term applicable to it; (5) that the name *Micropterus* was the first applied to the genus; and (6) that therefore, if we only take into consideration the priority of the names (irrespective of the applicability or erroneousness of the description), and combine the first specific names applied to the respective species with the first generic name given to a representative of the genus, the two species should be designated as (*a*) *Micropterus salmoides*, the small-mouthed black bass, and (*b*) *Micropterus nigricans*, the large-mouthed black bass.

The descriptions of the genus and its two species follow next in order.

MICROPTERUS Lac. *emend.*

SYNONYMY.

Micropterus *Lac.* Hist. Nat. des Poiss., iv, p. 325, 1800? (=Grystes, *fide Cuv. & Val.*, Hist. Nat. des Poiss., v, p. v, 1830).

Calliurus *Raf.*, Journ. de Physique, W. R. & M. Mag., i, p. 374, Jan., 1820; Ich. O., p. 26, 1820 (not Ag.).

Lepomis *Raf.*, Journ. de Physique, W. R. & M. Mag., ii, p. 50, Feb., 1820? Ich. O., p. 30, 1820.

(Lepomis) Aplites, n s. g. *Raf.*, W. R. & M. Mag., ii, p. 50, Feb., 1820? Ich. O., p. 31, 1820.

(Lepomis) Nemocampsis, n. s. g. *Raf.*, W. R. & M. Mag., ii, p. 51, Feb., 1820?; Ich. O., p. 32, 1820.

(Lepomis) Dioplites, n. s. g. *Raf.*, W. R. & M. Mag., ii, p. 52, Feb., 1820? Ich. O., p. 32, 1820.

(Etheostoma) Aplesion, n. s. g. *Raf.*, W. R. & M. Mag., ii, p. 56, Feb., 180? Ich. O., p. 36, 1820.

Huro *Cuv. & Val.*, Hist. Nat des Poiss, ii, p. 124, 1828.

Grystes *Cuv. & Val.*, Hist. Nat. des Poiss., iii, p. 54, 1829.

Grystes *Agass.*, Lake Superior, 295, 1850.

Dioplites *Girard*, U. S. Pac. R. R. Expl. and Surveys, x, Fishes, p. 4, 1858.

Micropterus *Gill*, Ann. Rep. Dep. Agric., 1866.

Labrus sp., *Lac.*

Bodianus sp., *Raf.*

Cichla sp., *Les.*

Centrarchus sp., *Kirtland, DeKay, Storer*, etc.

Body ovate-fusiform, compressed, deepest behind the ventrals, with the caudal peduncle elongated, scarcely contracted towards the base of the fin.

Scales small or moderate, quadrate, rather higher than long; with the exposed portion densely muricated, rounded behind and

about twice as high as long; with the fan with few (4–9) folds; extending to the nape and throat.

Lateral line regularly parallel with the back, in scales nearly like but smaller than the adjoining ones.

Head compressed and oblong conic, with the lower jaw prominent and the profile rectilinear; with scales (more or less smaller than those of the trunk) on the cheeks, operculum, suboperculum and interoperculum. ((1) none or (2) few on the preoperculum); operculum ending in a flattened point (spine) and with the border above it emarginated; suboperculum with a pointed membrane extending beyond (behind and above) the opercular spine; preoperculum entire. Eyes moderate, about equidistant from the snout and preoperculum; nostrils normal; anterior with a posterior lid; posterior patulous.

Mouth, with the cleft moderately oblique, large (the supramaxillary (1) nearly to or (2) beyond the vertical of the posterior border of the eye). Supramaxillary with the accessory ossicle well developed. Lips; upper, little developed; lower, moderate on the sides, but separated by a very wide isthmus.

Tongue moderate and free.

Teeth on the jaws in a broad band, acute, curved backwards, and increasing in size towards inner rows; on the vomer, palatines and pterygoids, villiform.

Branchiostegal rays six (exceptionally seven) on each side.

Dorsal with its origin behind the axil of the ventral; (1) its spinous portion longer but much lower than the soft portion, with ten spines more or less graduated before as well as behind and the ninth much shorter than the tenth; (2) the soft portion well developed.

Anal with its base shorter than the soft portion of the dorsal, nearly coterminal with it, with three spines, of which the third is much the longest.

Caudal emarginated and with obtuse lobes.

Pectorals and ventrals normal.

This enumeration of the characters common to the known forms of the genus has been drawn up with a view to exhibit the features differentiating the genus from the other representatives of the family Pomotidæ. The difference indicated by the general expression is coördinated with the greater distance of the eye from the preoperculum, the armature of the operculum, the pecul-

iar form of the dorsal and the relatively small size of the anal fin. The elucidation of the anatomical characters of the genus and comparison thereof with those of other genera are reserved for a future occasion when the distinctive features can be illustrated.

MICROPTERUS SALMOIDES (LAC.) GILL.

THE SMALL-MOUTHED BLACK BASS.

SYNONYMY.

(1)

Labrus salmoides *Lac.*, Hist. Nat. des Poiss., iii, pp. 716, 717, pl. 5, f. 2, 1800?

Grystes salmoides *Cuv.* and *Val.*, Hist. Nat. des Poiss., iii, p. 54, pl. 46, 1829.

Grystes salmoides *Jardine*, Nat. Lib., Perches, p. 158, pl. 29, 1835 (copied).

Grystes salmoides *DeKay*, Nat. Hist. N. Y., iv (Fishes), p. 26, pl. 69, f. 223, 1842 (copied).

Grystes salmoides *Storer*, Mem. Am. Acad. Arts and Sci., n. s., ii, p. 288; *ib.*, Syn. Fishes N. Am., p. 36, 1846 (copied).

Grystes salmoides *Val.* (Cuv., Regne Animal, ed. par disc. de Cuv.), Poissons, Atlas, pl. 9a, f. 2, p. 18.

Grystes salmoides *Herbert*, F. F. Fish and Fishing U. S., p. 197 (copied).

Grystes salmoides *Gthr.*, Cat. Fishes B. M., l, p. 252, 1859 (Lake Erie).

(2)

Micropterus Dolomieu, *Lac.*, Hist. Nat. des Poiss., iv, p. 325, 1800? (Grystes salmoides, *fide Cuv.* and *Val.*, Hist. Nat. des Poiss., v, p. 5, 1830).

(3)

Bodianus achigan *Raf.*, Am. Month. Mag. and Crit. Rev., ii, p. 120, Dec., 1817.

Lepomis achigan *Gill*, Proc. Acad. Nat. Sci. Phila., 1860, p. 20.

Micropterus achigan *Gill*, Rep. Comm. Agric., for 1866, 407, 1867.

(4)

Calliurus punctulatus *Raf.*, W. R. and M. Mag., i, p. 374, Jan., 1820; *ib.*, Ich. O., p. 26 (not Ag.).

(5)

Lepomis [Aplites] pallida *Raf.*, W. R. and M. Mag., ii, p. 50, Feb., 1820 (?); *ib.*, Ich. O., p. 30.

(6)

Lepomis [Aplites] trifasciata *Raf.*, W. R. and M. Mag., ii, p. 51, Feb. 1820 (?); *ib.*, Ich. O., p. 31.

(7)

Lepomis [Aplites or Nemocampsis] flexuolaris *Raf.*, W. R. and M. Mag., ii, p. 51, Feb., 1820 (?); *ib.*, Ich. O., p. 31.

(8)

Lepomis [Dioplites] salmonea *Raf.*, W. R. and M. Mag., ii, p. 52, Feb., 1820 (?); *ib.*, Ich. O., p. 32.

(9)

Lepomis [Dioplites] notata *Raf.*, W. R. and M. Mag., ii, p. 52, Feb., 1820 (?); Ich. O., p. 32.

(10)

Etheostoma [Aplesion] calliura *Raf.*, W. R. and M. Mag., ii, p. 56, Feb., 1820 (?); Ich. O., p. 36.

(11)

Cichla fasciata *Les.*, Jour. Acad. Nat. Sci. Phila., ii, p. 216, 1822.

Cichla fasciata *Kirtland* (Rep. Zool. Ohio); 2d Ann. Rep. Geol. Surv. Ohio, p. 191, 1838.

Centrarchus fasciatus *Kirtland*, Bost. Jour. Nat. Hist., v, p. 28, pl. 9, f. 1, 1842(?).

Centrarchus fasciatus *DeKay*, Zool. N. Y., iv, Fishes, p. 28, pl. 11, f. 8, 1842.

Centrarchus fasciatus *Storer*, Mem. Am. Acad. Arts and Sci., n. s., ii, p. 290; *ib.*, Syn. Fishes, N. Am., p. 38, 1846.

Black Bass *Brown*, Am. Anglers' Guide, pp. 189, 298, 1850 (Figure copied from DeKay's C. fasciatus).

Grystes fasciatus *Agass.*, Lake Superior, 295, 1850.

Centrarchus fasciatus *Thompson*, Civ. and Nat. Hist. Vermont, p. 131 (with fig.), 1853.

Centrarchus fasciatus *Gthr.*, Cat. Fishes B. M., i, p. 258, 1859 (copied).

Grystes fasciatus *Eoff.*, Smith's Rep. for 1854, p. 289, 1855.

Grystes fasciatus *Putnam* (Storer's Hist. Fishes Mass., p. 278), Mem. Am. Acad. Arts and Sci., ix, 1867 (Mass.).

Micropterus fasciatus *Cope*, Proc. Acad. Nat. Sci. Phila., 1865, p. 83 (Michigan).

Micropterus fasciatus *Cope*, Jour. Acad. Nat. Sci. Phila., 2d ser., vi, p. 216, 1868 (West. Va., etc.).

Micropterus fasciatus *Cope*, Proc. Am. Phil. Soc., xi (?), p. 450, 1870 (N. Car.).

(12)

Gristes nigricans *Herbert*, F. F. Fish and Fishing U. S., p. 195 (25, 197), with fig. (Not Huro nigricans *Cuv* and *Val.*).

Grystes nigricans *Garlick*, Treat. Art. Propag. Fish, p. 105 (with fig.), 1857.

Grystes nigricans *Norris*, Am. Anglers' Book, p. 103, 1864.

(13)

Cichla ohiensis *Les.*, Jour. Acad. Nat. Sci. Phila., ii, 218, 1822.

(14)

?Cichla minima *Les.*, Jour. Acad. Nat. Sci. Phila., ii, p. 220, 1822.

Cichla minima *Kirtland* (Rep. Zool. Ohio<), 2d Ann. Rep. Geol. Surv. Ohio, p. 191, 1838.

(15)

Centrarchus obscurus *DeKay*, Nat. Hist. N. Y., iv, Fishes, p. 30, pl. 7, f. 37 (really 48).
Centrarchus obscurus *Storer*, Mem. Am. Acad. Arts and Sci., n. s., ii, p. 292; *ib.*, Syn. Fishes N. A., p. 40, 1846.
Centrarchus obscurus *Gthr.*, Cat. Fishes B. M., i, p. 258, 1859 (copied).

Scales small, in about seventy to eighty oblique rows between the head and caudal, and eleven longitudinal ones between the back and lateral line, decreasing very much towards the nape and (especially) the breast; forming a sheath encroaching considerably upwards upon the soft portion and last spine of the dorsal. Head transversely (slightly) convex between the orbits, with (1) scales on the operculum larger than those of the nape, (2) on the sub-operculum (in front) in two rows, (3) on the interoperculum narrow, mostly invested in the membrane (in one row), (4) on the cheeks very small (in about seventeen to twenty rows), and (5) on the preoperculum none. Mouth moderate, the gape from the symphysis to the angle being little more than one-third (1 : $2\frac{1}{3}$) of the head's length. Supramaxillary ending in advance of vertical from the hinder margin of the orbit (about under the posterior border of the pupil).

Dorsal fin with its anterior spines rapidly graduated (I=1; II =1·5; III=1·90; IV=2·05; V=2·30) to the fifth; fifth, sixth and seventh longest and about equal to the space between the back and lateral line; the succeeding ones very gradually diminishing to the ninth which is shortest (three-fourths—1 : 1·25—of fifth) the tenth being about as long as the eighth and about a third shorter than the longest, *i.e.* fifth.

Dorsal fin with scales differentiated from those of the sheath and advancing high up on the membrane behind each soft ray (except the last two or three).

Anal fin with scales ascending high on the membrane behind the several rays.

Color, in young and adolescent, bronzed grayish, with (1) irregular darker spots tending to arrangement in three series alternating with each other above the lateral line and (2) indistinctly maculated with darker and yellow below; head dark above, gray on sides, with three oblique or horizontal bands, viz:—(1) from margin of upper jaw to below angle of preoperculum, (2) from lower angle of orbit to margin of preoperculum, (3) from hinder

border of orbit to angle of operculum, and with a crescentiform band (curved forwards) in front of the forehead between the eyes: spinous dorsal simply punctulated with dark; the soft with a series of bronzed spots between the respective rays; anal greenish with a marginal band of grayish-white: in adults the markings are more or less obliterated and the color a uniform dead green.

MICROPTERUS NIGRICANS (Cuv.) Gill.

THE LARGE-MOUTHED BLACK BASS.

SYNONYMY.

(1)

Huro nigricans *Cuv.* and *Val.*, Nat. Hist. des Poiss., ii, p. 124, pl. 17, 1828.
Huro nigricans *Rich*, Fauna Boreal., Amer., iii, p. 4, 1836.
Huro nigricans *Jardine*, Nat. Lib., i, Perches, p. 108, pl. 6, 1835.
Huro nigricans *DeKay*, Zool. N. Y., part iv, Fishes, p. 15, pl. 224, 1842.
Huro nigricans *Storer*, Mem. Am. Acad. Arts and Sci., ii, p. 277, 1846; *ib.*, Syn. Fishes, N. Am., p. 25, 1846.
Huro nigricans *Gthr.*, Cat. Fishes B. M., i, p. 255, 1859 (copied).
Grystes nigricans *Agass.*, Lake Superior, p. 297, 1850 (excl. syn. part).
Micropterus nigricans *Gill*, Rep. Comm. Agric. for 1866, p. 407, 1867.
Micropterus nigricans *Cope*, Proc. Acad. Nat. Sci. Phila., 1865, p. 83 (Mich.).
Micropterus nigricans *Cope*, Proc. Am. Phil. Soc., xi, p. 451, 1870 (N. Car.).

(2)

Grystes nobilior *Agass.*, Am. Jour. Sci. and Arts (2), xvii, p. 298, 1854.
Grystes nobilior *Putnam*, Bull. Mus. Comp. Zool., i, p. 6, 1863 (name only).

(3)

Grystes nuecensis *Baird* and *Girard*, Proc. Acad. Nat. Sci., Phila., vii, p. 25, 1854.
Grystes nuecensis *Gthr.*, Cat. Fishes B. M., i, p. 252, 1859 (doubtful sp.—name only).
Dioplites nuecensis *Girard*, U. S. Pac. R. R. Expl. and Surveys, x, Fishes, p. 4, 1858.
Dioplites nuecensis *Girard*, U. S. Mex. Bound. Survey, ii, Ichthyology, p. 3, pl. 1, 1859.

(4)

Grystes salmoides *Holbrook*, Ich. S. Car., p. 25, pl. 4, f. 2, 1855; *ib.*, 2d ed., p. 28, pl. 4, f. 2, 1860(?) (not Cuv. and Val.).
Grystes salmoides *Norris*, Am. Anglers' Book, p. 99, 1864 (fig. and desc. copied from Holbrook); observations partly referring to *M. salmoides*.

(5)

Grystes megastoma *Garlick*, Treat. Art. Prop. of Fish, p. 108, 1857.

(6)

Oswego Bass *Brown*, Am. Anglers' Guide, p. 189, 1850.
Oswego Bass *Norris*, Am. Anglers' Book, p. 110, 1864.

Scales moderate, in about sixty-five oblique rows between the head and caudal, and eight (or seven and a half) longitudinal ones between the back and lateral line, decreasing little towards the nape but more towards the throat; with the sheath enveloping the base of the soft portion of the dorsal very low and developed towards the end of the fin. Head flat between the orbits, with (1) scales on the operculum about the size of those of the nape, (2) on the suboperculum broad and in one row, (3) on the interoperculum broad, conspicuous and regularly imbricated, in one row, (4) on the cheeks moderate (in about ten rows in an oblique line, and five or six in a horizontal one), and (5) on the preoperculum (two to five) in an incomplete row. Mouth large, the gape from the symphysis to the angle of supramaxillary equalling nearly a half of the head's length. Supramaxillary not continued backwards decidedly beyond the vertical from the hinder border of the orbit.

Dorsal fin with the anterior spines slowly graduated (the first being comparatively long) to the third (I=1; II=1·30; III=1·50); fourth longest (but little more so than the third) and equal to or exceeding the interval between the back and lateral line; succeeding ones successively and in increased ratio abbreviated to the ninth, which is very short (two-sevenths—1: 3·5—of fourth), the tenth being longer than the eighth (shorter than the seventh) and about two-thirds as long as the longest (*i.e.*, fourth).

Dorsal fin with scales ascending comparatively little behind on the membrane behind the soft rays (none behind last five or six).

Anal fin with no (or very few) scales.

Color, in young and adolescent, greenish-black, verging to yellowish-white on lower sides and abdomen, with (1) a series of large blotches arranged in a regular line, from shoulder to caudal, on the middle of sides, the posterior third of which becomes a continuous stripe and (2) below this middle series, rather irregular, small blotches, with tendency to become a continuous stripe on posterior third of body. Head dark above, white from lower half of maxillary bone, and suboperculum to chin and throat, and with three oblique and horizontal bands upon cheek, viz.: (1) one from angle of upper jaw to margin of preoperculum, (2) one from

lower edge of orbit to angle of operculum, and (3) one radiating slightly upward from posterior margin of orbit to operculum. Apex of operculum with large dark spot, upper fins dusky, lower yellowish-white.

The stripes on the body frequently continue until the fish is well grown, though gradually becoming obsolete; black spots upon the scales remain more or less permanently, giving the appearance, in old fish, of fine lines or stripes. (Color *fide* J. W. MILNER, Mss.)

ON MOVEMENT IN THE STIGMATIC LOBES OF CATALPA. By THOMAS MEEHAN, of Germantown, Penn.

IT has long been known that the expanded lobes of the pistil in some species of *Mimulus* close when touched. In communications to the Academy of Natural Sciences of Philadelphia, I have shown that this power extends to other genera of scrophulariaceous plants, and even extends to *Bignonia* in an allied order.

I have not suggested any service to the plant by this motion; but recently a correspondent of the London "Journal of Botany," referring to the *Mimulus moschatus*, expressed his belief that it is one of the arrangements, recently discovered, whereby plants avoid self-fertilization and seek aid from insect agency. He says, in effect, that when a pollen-covered insect touches the stigma on entering, the cloven stigma at once closes, and thus avoids its own pollen which is taken out by the insect on its exit, and carried to another.

As it was but last winter that I observed the motion in *Tecoma jasminoides*, I have only now been led to look for it in *Catalpa bignonoides*, of the same natural order. I find it to have the same mótion, but in a very slow degree. It takes about one minute for the fully expanded lobes to close wholly. It would thus appear that in this case the motion can hardly have relation to insect fertilization, as an insect would be very unlikely to remain so long in one flower. On withdrawal it would introduce the flower's own pollen to the stigma long before the lobes closed. On reading the

suggestion referred to, I was prepared to accept the explanation from knowing how much the *Bignonia radicans* is frequented by the hummingbird, which I supposed might prove its fertilizing agent; but I find that no insect but a few honey bees frequent the Catalpa here, unless there be some nocturnæ which have escaped my observation. But these honey bees do not affect the stigma. The lobes remain open after their visit, and as they close on being touched afterward, it is clear the insect avoids them. Yet the trees produce seed in great abundance. Fertilization is probably effected here by wind.

It may be that, though the stigmatic motion may have no reference to insect fertilization in this case, it may have in the *Mimulus* and other cases; for there is evidence to show that in plants, as in animals, there are inherited tendencies which, valuable to one race or variety, are of no use to another springing from it, and which will gradually die away in time. Still this suggestion, so far as it relates to *Catalpa*, is met by one from an opposite point, namely: that plants which require the aid of insects in their fertilization are later creations in the order of time than those which are fertilized by wind. If, therefore, other allied plants require insect aid, the *Catalpa* ought to be acquiring a power rather than losing one. But these speculations are merely to indicate the direction of popular inquiries; the main object of the paper is to note the stigmatic motion in *Catalpa*, and the difficulty it presents to the acceptance of the insect fertilization explanation of it.

On Hermaphroditism in Rhus cotinus (the Mist Tree) and in Rhus glabra (Common Sumac). By Thomas Meehan, of Germantown, Penn.

I believe *Rhus cotinus* is generally regarded as hermaphroditic. Describers, referring to it, usually say it is so, or merely say, "flowers sometimes abortive." A friend informs me that, in a collection of plants from the south of Europe, he once saw both male and female specimens; and from experience with a large

number of plants on my grounds, I can say that here they are truly diœcious. It is probable that the error arose from the fact of our chief acquaintance with it being through cultivated specimens. But in late years nurserymen depended on layers for propagating it, and as the female form is the most desirable, that one has thus been rendered the best known. In all probability one original plant furnished most of those in cultivation. Somewhat recently, seed, probably from wild plants, has been extensively distributed by German seedsmen, and it is to these seedlings that the facts of this paper relate. The plants of the past—layered plants—"mostly abortive," as the books say, usually perfect their carpels; but these contain no seeds, so far as I have been able to find. In the male the gynœcium is almost wanting, while the stamens are fully developed, and the flower is nearly double the size of the female flowers. These are smaller, and have the merest rudiments of pistils.

This knowledge has more than usual importance from the fact that the "mist," as the hairy pedicels are popularly called, is only produced to any great extent by the female plant. The male flowers, not having the viability of the female, according to the laws already developed in my former papers on sex, die away soon after developing—pedicels, general axis and all. Sometimes the misty hair will become developed a few lines in length, before the inflorescence loses its vitality; and in three cases out of many hundreds vitality continued long enough to develop fair "misty" heads. The general rule, however, is for the male inflorescence to die entirely away soon after the anthers burst.

Another matter of interest is that in some vigorous developments (deemed vigorous from the great number and length of pedicels in one panicle) two carpels, and occasionally three, will be developed from a single flower, in the latter case forming a triangular capsule. This might be expected from the trifid pistil, but I believe the actual development has not been placed on record before.

It is worthy of remark that in most plants which have a hermaphroditic appearance, but are practically diœcious, the relative length of the stamens and pistils varies in the dimorphic conditions. In the one case, the truly female, the pistil is longer than the stamens, and the stamens are the longer in the male. In *Rhus glabra* there is a form considered hermaphroditic, in which the pistils

seem highly developed in the midst of perfect stamens, quite as much so as in the purely pistillate plant; but so far as my observations go, no pollen-bearing flowers ever produce seed. The pistillate plants of *Rhus glabra* also are several days later in coming into bloom.

Note on a New Sigillaria showing Scars of Fructification.

By J. W. Dawson, of Montreal, Canada.

ABSTRACT.

This new species is closely allied to the *S. Lalayana* of Schimper, and has been named *S. Lorwayana* from the Lorway coal mine in Cape Breton where it was found. Its description is as follows:—

Leaf-bases about 8^{mm} broad and 5^{mm} high, in trunks of moderate size, hexagonal with rounded angles, or approaching to oblong, sometimes a slight indentation below causes them to appear reniform. They are contiguous, or nearly so, in vertical rows, being separated from each other only by a slight ridge. The rows are separated by spaces of wrinkled bark nearly half as wide as the leaf-bases. Vascular scars near the top of the leaf-base, each having two minute and often confluent points and two larger and lunate lateral punctures.

Fruit-scars arranged in transverse rows forming a girdle, each member of the girdle consisting of from two to seven contiguous, vertical scars placed in the spaces between the leaf-scars in the vicinity of an articulation, where the rows of leaf-scars are not continuous, as if there had been an interruption of growth. These articulations are from two inches to a foot apart vertically. The scars are depressed or sunk into the stem, rounded or angular by pressure, having in the centre a small sunken ring and dot.

The bark appears to have been thin. Flattened specimens are sometimes a foot in diameter.

When the epidermis is removed, the inner surface appears rugose longitudinally, and there are transverse leaf-scars, each with

two vascular points, the whole presenting the appearance of the type *Leioderma*.

The author contended that the fruit-scars are evidently modified leaf-scars passing into these. They have thus no affinity, either in form or relation, with the large, round, cone-bearing scars of *Lepidofloios*, and they must either have borne single ovules or modified leaves with marginal fruit. The fruit may have been either *Trigonocarpa* or *Cardiocarpa*, and these may have been borne in racemes of the nature of *Anthoolites*. This view does not accord with that of Goldenberg and Schimper, but is in harmony with that stated by the author in "Acadian Geology," pp. 437, 438, 459.

ON AN ANCIENT BURIAL-GROUND IN SWANTON, VT. By GEORGE H. PERKINS, of Burlington, Vt.

ABOUT two miles north of the village of Swanton in northwestern Vermont is a sandy ridge, which was formerly covered by a dense growth of Norway pines; the thickly-set, straight trees resembling somewhat a huge growth of hemp. The place was at one time called "the old hemp yard," a name which still clings to it. Rather more than twelve years ago it was discovered that beneath this forest stone implements were buried, and further investigation has shown that the spot that was so covered with large trees and stumps, when the first white men came into the region, had been, ages before, used as a burial place by some people, whose only records are the various objects which the affectionate care of the living placed in the graves of the dead. From directly beneath the largest trees or half decayed stumps, some of these relics were taken, so that we may feel sure that before the great pines, which for many years, perhaps centuries, grew, flourished and decayed, had germinated, these graves were dug, and with unknown ceremonies the bodies of the dead were placed in them, together with those articles that had been used during life, or were supposed to be needed in a future existence.

We cannot know how many successive growths of trees may have followed each other since the forest began to usurp the place set apart for sepulture.

In the early days preceding the settlement of the country by the whites, two great nations, the Algonquins and Iroquois, occupied the region bordering the northern part of Lake Champlain. A branch of the Algonquins, the St. Francis tribe, as they were latterly called, were living on the banks of the Missisquoi River, near Swanton, when the place was settled by white men. These Indians had a village near the river, which had been occupied by them from ancient times. Near this village was a second and more recent cemetery, about four or five miles from that first named. Though this was evidently less ancient than that beneath the pine forest, and had been used up to comparatively modern times, it yet bore evidence of considerable antiquity. A brief account of both of these places was given by the late Professor J. B. Perry, at a meeting of the Boston Society of Natural History in December, 1868, which was printed in volume xii of the Proceedings of that Society, pp. 219–221. Professor Perry's account was evidently intended merely to call attention to the case and was probably given from memory without recent examination of the objects which he describes, as in many details his statements are inaccurate.

While, of course, the survivors of the St. Francis tribe, a few of whom lived near Swanton not many years ago, were acquainted with the burial place of their own tribe, they had no knowledge, as Professor Perry states, of the more ancient cemetery, not even a tradition that hinted of its existence. That it belonged to a different people is shown by the character of the articles found, as they differ in many respects from those taken from the graves of the St. Francis tribe, being of finer material for the most part, of different shape, more elaborately wrought and altogether giving evidence of a higher degree of culture than that to which the Iroquois or Algonquins attained.

For many facts concerning this more ancient burial place I am indebted to Mr. H. H. Dean of Swanton, who has opened more of the graves than any one else and who has been careful to ascertain the exact truth in regard to all the excavations. His statements are corroborated by others and by my own investigations.

That the pine forest of the old hemp yard covered the remains

of some of the ancient inhabitants of the country was not suspected until discovered by accident, there being nothing on the surface to indicate anything of the sort, not even mounds of any kind, though small ones may have originally existed and been obliterated during subsequent changes. Twenty-five graves at least have been opened at this place and, though at present no more can be examined, it is probable that more, perhaps many more, yet remain untouched, and others still have very likely been uncovered by the wind, and their contents scattered, for the light sand, in which the graves were dug, has been for quite a long time blowing off. Those graves that were earliest opened were at least six feet below the surface, as Deacon E. Frink, who opened them, states, but those that have since been discovered have none of them been as deep, some less than two feet; in all cases since, perhaps, the first one or two graves were opened, the surface material had blown off, or been disturbed so much that it is not possible to determine the precise depth of the graves, when the bodies were placed in them.

The sand in which the graves were dug is of a very light color, but that immediately around and beneath the body was, with two exceptions, colored a dark red or reddish-brown; in the exceptional cases it was black. This red sand was from four to six inches in depth and its color was undoubtedly due to the presence of red iron oxide, or red hematite, small pieces of a compact, deep red variety of that mineral having been found in several of the graves. These bits of ore, while pretty easily giving color to water when powdered, are not soft enough to have caused the coloring of the sand by staining such water as might have trickled through it, so that the oxide must have been powdered and mixed with water, or, less probably, with the blood of some animal, and poured into the graves as a part of the funeral rites. As nearly all of the objects taken from the graves are stained, as well as the sand, it is probable that the coloring material was poured over the body and such objects as were deposited with it after they were placed in the grave. The black color mentioned was due probably to the decomposition of organic matter, no coloring liquid having been poured into those graves.

The skeletons found in the graves were much decomposed, only two bones, a femur and a radius, being entire, though several others are nearly whole, among the rest nearly half of a skull;

but most of the bones crumbled more or less on exposure to the air. The skull I have not been able to examine with care. As to the position of the body in the grave I am unable to assert anything positive with reference to most of the graves, though it is probable that most were buried in a sitting posture facing the east. In a few cases I am sure of this. Deacon Elliott Frink, upon whose land the graves were found, states that he dug open several of the graves that were first examined, and that he found one body, that of an adult person, buried in a perpendicular position with the head downwards, and that in this grave no implements were found except a few arrowheads. If the body really was buried in this singular position it is a fact of great interest, and suggests the disgrace and punishment of some great criminal, inflicted not only during life, but carried even into his dishonorable burial. But we cannot be so sure of the fact of this unheard-of burial as we should like to be. While we have entire confidence in the honesty and truthfulness of the person who observed the apparent fact, we must bear in mind the ease with which one unused to such investigations might be deceived. My friend, Mr. F. W. Putnam of Salem, an excellent authority in archæological matters, states that it not very infrequently happens that, after the decomposition of a body buried in a sitting posture, the head drops down between the legs or feet, and it is possible certainly that by a sinking of the soil and by such displacement of the ground as might easily enough be caused in digging open the grave, if the digger were not sure of the position of the body, or careful not to displace anything, such a change of position in the skeleton might be caused as to make it appear to have been originally deposited in a position quite different from that in which it really was. I do not intend to assert that it is not possible that the body mentioned was buried head downwards, but only that it is much more probable that it was not.

Through the kindness of Dr. G. M. Hall and Mr. H. H. Dean, of Swanton, and Dr. Hiram Cutting, Curator of the State Cabinet, I have been able to examine a full series of implements taken from the graves. In all, I have studied not far from a hundred articles, and, so far as I can discover by diligent inquiry in and about Swanton, this series includes at least two-thirds of all that have been found.

As the result of a careful comparison of the various implements

found in the Swanton graves with those from mounds in the west, I am convinced that in the Swanton relics we have evidence that at some time a branch of the mound-building race wandered eastward, perhaps following the St. Lawrence, and found their way to the region on the Missisquoi River near Lake Champlain, where we now find their remains. From the comparatively small number of graves, and from the fact that we have graves but no attempt at the formation of any mound, I am inclined to infer that the people who thus strayed from the main body were few in number, and perhaps their residence in Vermont was not of long duration.*

For proofs of the relationship of the people of the Vermont graves to those of the mounds of the Mississippi valley, the reader is referred to some of the articles described farther on, some of them being, as will be noticed in connection with them, identical, except in some unimportant details, with some of those figured and described by Squier in the first volume of the Smithsonian Contributions.

Moreover we have evidence elsewhere in Vermont of the presence of the mound-builders. A copper spear point, found not far from Burlington, is almost exactly like one figured in Dr. Foster's late work on "Prehistoric Races of the United States," page 255, fig. 53*e*, which he regarded as an implement of the mound-builders. The Vermont specimen differs only in being narrower, and the edges of the shank are not bent over so far, being more as in fig. 55, p. 258, of the same work. Quite a number of stone implements have been found in different parts of Vermont which closely resemble others from the Mississippi valley, yet it may properly be stated that the relics from the Swanton graves form a collection unique in itself and quite different from collections of similar objects from the state at large. No pottery of which I am aware has been found in any of the graves, though several fine examples have been dug up not very far from Swanton.

Besides implements of definite form and use several objects have been obtained in the Swanton graves, which, though apparently of little use, may have been preserved as objects of curiosity. Among these is a mass of gnarled spruce or pine, having somewhat the

* The absence of mounds where the graves are found does not necessarily prove that none ever existed, for the soil is so light and easily moved by the strong winds to which it is often exposed that, as soon as the grass or other vegetation that may be growing in the sand is removed, extensive excavation soon follows. Hence mounds of some size might have been made and yet no trace of them now exist.

appearance of a sphere bearing upon its surface quite irregularly conical protuberances. It is wrought only a little and was probably formed in the roots of a tree where very likely several roots started from the main stem at neighboring points. It is about twice as large as one's doubled fist and would attract the attention of any one seeing it, as being much like a rude carving. A smooth water-worn pebble of white quartz, weighing just a pound, was found in one grave; it is about four inches long, three wide and one thick and of oval shape. One side was deeply stained with the so-called paint, and it may have been used for grinding the iron oxide that was to form the basis of the coloring material to be poured into the graves of the dead or used as paint for the bodies of the living. In another grave was a piece of black shale resembling the Lorraine shales of New York. It is about six inches long, three or four wide and a fourth of an inch thick. It does not seem to have been wrought in any way, but it bears distinct cavities, the matrices of fossils that had dissolved out, thickly scattered over it, and these undoubtedly made it attractive. From another grave came a much larger piece of the dark red Potsdam sandstone, found at Highgate, just north of Swanton. This is covered over a part of its surface with casts of Obolella, Conocephalites and other characteristic fossils. One end is broken off, the remaining sides are all rudely squared and smoothed, so that the general form of the stone is that of a brick. As the fossils in this stone are very inconspicuous and the stone itself unattractive, it is difficult to see what there was in it especially interesting. Only a very small proportion of the objects taken from the graves can be classed among those just mentioned, by far the larger number having evidently been made for some definite use; these are formed of copper, of shell and of stone.

Implements of copper are not at all common, not more than eight or ten in all having been found. The largest of these, that shown in fig. 1, is somewhat chisel-shaped or long triangular; the surfaces are slightly convex and the corners are bevelled along the sides very regularly. The broad surfaces are tolerably smooth, but are dented as if struck from end to end with some tool having a blunt edge. Neither end of this instrument is brought to an edge, but the broadest end is thinnest. Along each side runs a regular and rather deep groove. When first taken from the ground by Mr. Dean it had fragments of wood adhering to it, and

it still bears impressions upon its corroded surface of woody fibre. It was probably a point projecting from a war club, the broader and thinner end being inserted in the wood, the dents, just mentioned, serving to hold it in place and the more nearly square pointed end projecting. Its surface is badly corroded and the wood found with it speedily crumbled on exposure to the air. It is 5·9 inches long, 1·2 inches broad at one end and ·4 inch at the other, ·15 inch thick at broad end, ·45 inch near the middle and ·25 inch at the narrow end, and its weight is 6·25 ounces, Troy. It is in the collection of Mr. Dean. Fig. 1 shows this implement, one-half natural size. Like all the other articles of copper it is of the pure native copper of Lake Superior. Fig. 2 represents a chisel also reduced one-half. This implement is smoother than the other and seems rather more carefully formed; it is also thinner; the corners are not bevelled, but left sharp, and the ends are more nearly equal in breadth. It is, as the drawing shows, smaller, being 4·4 inches long, ·6 inch and 1·2 inches wide at the ends and ·2 inch thick near the middle. Figs. 3 and 4 are reduced drawings of bars of nearly the same length and weight, though fig. 3 is rather larger. This was found held in the teeth of a skull. Its corners are bevelled so that a cross section is octagonal, but, as the surfaces made by this bevelling of the corners are quite narrow, the other four are much wider and two of these are grooved, each by a rather shallow furrow, much like that on each edge of fig. 1. The ends taper to very blunt and rather irregular points. The entire length is 4·7 inches, greatest breadth ·35 inch, greatest thickness ·3 inch. Fig. 4 differs from this in being cylindrical and having its ends more regularly tapered. Its length is nearly the same as that of fig. 3, but its diameter is less, being nowhere more than ·27 inch.

Besides the larger articles quite a number of tubes have been found which are quite like those taken from some of the mounds of the west. They are so much corroded and broken that it is not possible to determine their original length, but as they now are this varies from ·5 inch to 2 inches. The diameter does not vary much, it being from ·2 inch to ·3 inch. These tubes are made from sheets of beaten copper rolled together, and, as the inner edge remained flat for a short distance, the surface of the tube above this is flat, as often occurs when any stiff material is rolled. Be-

sides being corroded the surfaces of the bits of tubing are dented and battered as if they had been subjected to rough usage.

Objects made from shell are more numerous, though all of the same general form—that of beads, as may be seen in figs. 5, 6 and 7. In all, thirty of these shell ornaments have been found. They were formed from the columellæ of large shells, such as Fascialaria and Strombus.

Where the surface of the shell was smooth it was left as it was found, while the irregular ends and sides, where the fragment that was to be used was broken from the rest of the shell, were rubbed smooth and the whole made more or less regular in shape, and perforated, as will soon be described. In size these beads vary greatly, the largest being over two inches long and an inch in diameter and the smallest not more than half an inch long and a quarter of an inch in diameter. The longer and more slender specimens, such as fig. 7, are more common than those that are shorter and thicker, such as fig. 5; the more common size perhaps is from an inch and a quarter to an inch and a half long and one-fourth of an inch, or a little more, in diameter. They are all perforated, though not exactly in the same manner. In some, as fig. 5, the hole runs directly from end to end, in others, as fig. 6, a hole is bored for a short distance into each end, until it meets a second aperture caused by boring from one side down upon the former, and so meeting it at right angles, or, as in fig. 7, there is a hole running from end to end, which is met by a single transverse opening. Besides the fragments of the columellæ of large shells, one or two entire specimens of the small *Marginella conoidalis*, so common on the Florida coast, were found. These were drilled longitudinally through the spire. Thus, while the articles of copper show that the ancient people, whose works we are studying, had intercourse, directly or indirectly, with tribes living near the Lake Superior copper region, so these shell beads show a similar communication with the southern portion of the country.

As would naturally be expected, the greater number of articles obtained from the graves are of stone. Perhaps most interesting among these, are certain tubes, shown in figs. 8 to 10. They are of a light drab color, except where stained by the iron oxide already mentioned. They are all probably of stone; some seem undoubtedly of this material, while a few look very much as if made of baked clay, but experienced potters to whom I have shown them

Fig. 3.

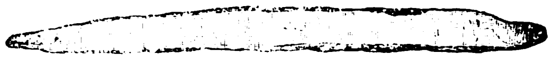


Fig. 4.

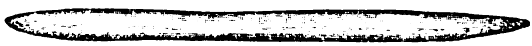


Fig. 2.

Fig. 1.

Fig. 6.

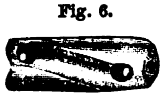
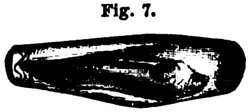


Fig. 5.

Fig. 7.



Figs. 1, 2, 3, 4. COPPER IMPLEMENTS.
Figs. 1 and 2 about ½ full size; 3 and 4 about ⅔ full size.
Figs. 5, 6, 7. SHELL BEADS; full size.

Fig. 11.

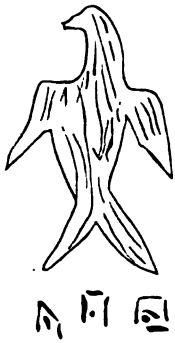


Fig. 8a.

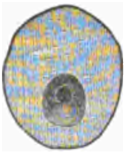


Fig. 8b.

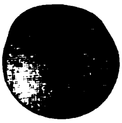


Fig. 12.

Fig. 10.

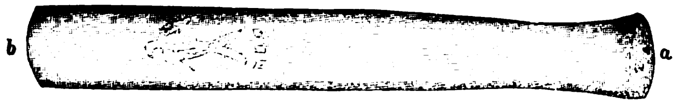


Fig. 9.

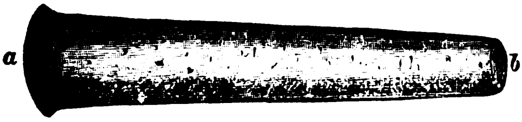
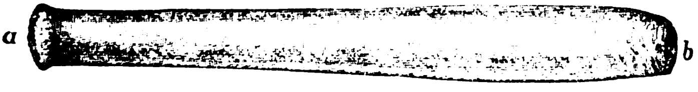


Fig. 8.



TUBES OF STONE.

Fig. 8, ¼ size; 9 and 10. ⅓ size.
Figs. 8a, and 8b, represent the ends of fig. 8, of about ½ size.
Fig. 11 represents the engraving on fig. 10, of full size.
Fig. 12 represents a stone plug found in the small end of one of the tubes.

pronounce them all of stone. The tubes are none of them of uniform size throughout their length, but are always largest at one end, and often both ends are larger than the middle. There are three somewhat diverse forms found; one is shown in fig. 8; this, like all the rest, begins to contract rapidly at the end, but, after about an inch, it changes and enlarges very gradually till within about two inches of the opposite end, when it again contracts, the whole shape being a good deal like that of an ordinary ball club. The length of the tube, shown in fig. 8, is 13 inches; its greatest diameter is 1·35 inches. Another form is seen in fig. 9, in which the greatest diameter is at one end, from which the tube contracts, at first rapidly, but soon slowly to the other end. The tubes of the first-named form are largest, those of that just described smallest, while an intermediate form and size is that given in fig. 10. In these, the tube contracts rapidly from one end for an inch or so and then enlarges gradually to the opposite end. Both ends of the tubes are cut off squarely. All are perforated in the same general manner, the hole running directly from end to end, and being about twice as large at one end as at the other, *e.g.*, in the largest tube found, that shown in fig. 8, the bore is ·95 inch in diameter at one end and ·52 inch at the other; in fig. 10 it is ·9 inch at one end and ·4 at the other, and so on. The larger end of the bore seems to have been scraped out, after the main portion of the hole was made, by some thin edged instrument, as the circular striæ which are very numerous elsewhere are here replaced by longitudinal. This larger end of the aperture is always nearly as large as the tube, only a thin shell of the material being left, while at the opposite end, and indeed throughout most of the length, the walls are thick; the relative appearance of these is shown in figs. 8*a* and 8*b*, reduced one-half. As seen in fig. 8*a*, so in the other tubes, the smaller end of the bore is not in the middle but always one side of it. Into this smaller end of the bore was inserted a stone plug, like fig. 12; these plugs were not all carefully made and did not often entirely fill the aperture; in one or two cases a small quartz pebble with little or no working was used, though most are of sandstone. They are from ·75 inch long and ·5 inch in diameter to not more than ·5 inch long and ·4 inch in diameter at the larger end. The tubes are rarely perfect cylinders, but are more or less oval in section.

All the tubes show considerable care in their formation; the

materials differ somewhat, some being hard, others quite soft, though the hardest are easily scratched by a knife, and all appear to be made of a sort of argillaceous sandstone, the sand predominating in the harder and the clay in the softer. The surface of most is very smooth and shows but few marks of the tools by which they were wrought.

One of the tubes, that shown in fig. 10, is especially interesting on account of certain markings upon it; these are, so far as I am aware, the only marks that have been discovered upon any article taken from the graves. They are near one end of the tube and consist of the outline drawing of some bird, below which are three characters. These objects are engraved or rather scratched on the tube—the scratches being somewhat irregular and neither very deep nor wide, and some are very fine; they are shown of full size in fig. 11, while their position on the tube is shown in fig. 10, which is reduced to one-third size. The bird, which somewhat resembles more recent delineations of the fish-hawk, and may have been intended for it, is 1·4 inches long and ·65 inch broad across the wings. The three characters below the bird are, as may be seen, made up of straight lines and dots, and are about a quarter of an inch high and a little less broad.

In the notice of these graves before mentioned, Prof. Perry remarks that these, "curious hieroglyphics of undoubted antiquity" to his mind "give almost unmistakable evidence, if not of Asiatic origin, at least of a people closely allied in their sentiments and habits to the nations of the East." "Reference is now made to tubes, etc., etc., ornamented with hieroglyphics of a moral or religious character." "These symbols as far as I can make them out are closely akin to those employed as well in the Eleusinian rites, as in the old Cyribaic mysteries of Samothrace."* As the only hieroglyphics that have been found in the Swanton graves are those given in fig. 11, the reader is referred to that and can use his own judgment as to the moral or religious bearing thereof. I can hardly think that he will be very deeply impressed by either, and as to the proof of Asiatic origin afforded by these few scratches, it is scarcely conclusive to every one.

Those who are seeking constantly to find evidences of Israelitic origin in the former inhabitants of this country may indeed be struck by the resemblance of these three characters to Hebrew

* Proceedings Bost. Soc. Nat. Hist., vol. xii, p. 220.

letters, but most of us will hardly be willing to place any such value upon them. That they are curious and interesting we are not disposed to deny and even that the last two characters might be read as Hebrew letters rather rudely formed, is unquestionably true, but yet this proves very little because it proves too much, as it proves too advanced a civilization. Had we evidence in the implements, ornaments, modes of burial and similar records that have come to light, of any such civilization as would admit of the use of a written language by the mound-builders, to whom, as already stated, I believe these people to have belonged, we then might seek for some significant meaning in these characters, but we have no proof that anything of the sort existed. It must not be forgotten that the possession of a phonetic alphabet implies a high degree of culture—a culture and a civilization that has passed far beyond pictorial writing and reached the last and highest stage in the development of language. As we have no reason to believe that the mound-builders had reached this advanced stage and as we have abundant reasons to convince us that they had not, we may set aside all idea that the few scattered symbols that so resemble phonetic characters have anything in common with such characters, beyond the mere resemblance; therefore I do not regard those characters given in fig. 11 as anything more than accidental—as probably having no more meaning than the various combinations of lines which a child makes on its first slate. I have written more at length upon this point than perhaps the case demanded, but, as quite a number of persons to whom I have shown my drawings, who were not experienced in archæological matters, have appeared deeply impressed by the resemblance of these characters to those of oriental alphabets, as Prof. Perry evidently was, I have thought that some discussion of the question would not be useless. Few indeed are they who will see in them anything suggestive of the mysterious religious ceremonies of Samothrace, or the worship of Ceres at Eleusis.

One, and only one, of the tubes shows any signs of having been near the fire, but this one, which is in the state collection at Montpelier, is blackened and badly cracked as if for some length of time exposed to severe heat. In all about a dozen of these tubes have been found in the graves at Swanton, while, so far as I can learn, nothing of the sort has ever been found elsewhere in the state. The largest is thirteen inches long and holds a little more

than a fifth of a pint. Measurements of others giving extreme as well as intermediate sizes are given below.

	No. 1. Fig. 9.	No. 2.	No. 3. Fig. 10.	No. 4.	No. 5. Fig. 8.
	Inches.	Inches.	Inches.	Inches.	Inches.
Length	7.1	8.	9.5	10.	13.
Diameter of ends marked *a*. in fig. .	1.35	1.35	1.2	1.3	1.35
" " " *b*. " .	1.	1.	1.15	1.1	1.2
" of bore in end *a*. " .	.45	.45	.4	.5	.52
" " " *b*. " .	.8	.8	.9	.8	.95

I do not find that tubes very nearly resembling these have been found anywhere else, though a few that have a general similarity have been taken from western mounds.

Schoolcraft, in plates 32 and 33 of the first part of his extensive work on Indian tribes of the United States, figures several that he says were made of steatite. These seem to be of a regular, cylindrical form. He also figures several formed of bone from Canada, but these bear very little resemblance to our Swanton tubes.

Squier also in vol. i of the "Smithsonian Contributions," pp. 224–227, figs. 122–125, describes and figures six tubes, all different from each other, and from our Swanton specimens. These are all from the Mississippi valley. In size they agree pretty well with the Vermont tubes and it is quite likely that their uses may have been the same, but what those uses were it is not easy to decide. Some have regarded them as musical instruments, but it is not by any means plain how they could have served such a purpose. Squier remarks in regard to the tubes he had seen, "that the skill of the present succeeds in producing very indifferent music from them. Either the art of playing upon them has sadly deteriorated, or the musical taste of the makers was not regulated by existing standards" (S. I. Contr., vol. i, p. 226). To the tubes we have described, these remarks apply with double force, when we consider that all of them were stopped at one end. It is possible that, connected with some parts now lost, these tubes may have served as musical instruments, and then a savage yell

sent through one of them may have been sweeter to savage ears than the music of our finest instruments.

Mr. Schoolcraft's notion, that the tubes he studied might have been used as telescopes, would hardly do for the Swanton tubes, for the quartz or sandstone plugs could scarcely have taken the place of lenses. Others have supposed that they might have served as tubes for smoking, but no evidence of such use remains. Most, if not all, of those in the west are of ornamental stone, while the lack of ornament, either in material or form, in the Swanton tubes seems to indicate that they were for use rather than for ornament. A small piece of an oval dish of the same, or similar, material as that of the softer tubes was found with them, and other dishes, very nicely made, have been found in different parts of the town, which not improbably were made by the same persons as those who formed implements taken from the graves, as the skill shown in their manufacture indicates a greater proficiency in such arts than any shown by the Algonquins.

Quite a number of flat plates of stone occurred in the graves, which may be arranged in a series, from those quite rudely finished to such as are very carefully formed and smoothed; those which are most carefully finished are of hardest and most compact stone. Perhaps the simplest is of diamond shape the sides being slightly unequal. It is not entirely flat but somewhat undulating over its surfaces, as they are left just as the cleavage of the stone formed them. The material is of greenish-gray mica schist with transverse dark veins. It is 3·5 inches long, 2·3 inches broad and about ·48 inch thick. It is in the state collection. In Mr. Dean's collection is another plate of rectangular form, larger and rather more finely finished than the preceding, the longer sides are nearly parallel though not quite straight; its upper end is straight while the lower is regularly, though not strongly, curved. The surfaces are smooth, one is flat, the other somewhat irregularly bevelled in several directions. It is composed of a dark greenish slate, obliquely veined with a darker shade so that it is quite attractive in its appearance. Its length is 4·15 inches, breadth 1·9 inches, and average thickness about ·4 inch, but this is very variable. In the state collection is a yet more nicely finished plate of compact, purple slate, like that first described; it is rectangular, the surfaces smooth, flat and sloping gradually towards the edges, so that these are thinner than the general surface. The corners are

slightly rounded and the sides not perfectly straight. It is 4·35 inches long, 2·2 inches broad and from ·1 to ·2 inch thick. It is not certain, I think, whether these plates had in themselves a definite use, such as to smooth skins or rub seams sewed in them, or some other such domestic use, or were simply unfinished articles like those about to be described. The least carefully wrought of these is much more regular and better finished than any of the simple plates. All of this second class are perforated with two holes. In one of them the form is rectangular, with one surface flat, the other convex. It is made of dark veined slate, much like that of which one of those just described was made. The sides are straight and the edges sharp and clearly cut; one end is a little narrower than the other, as is often the case with the rectangular plates. It is 4·25 inches long and at the broadest end 1·35 inches wide, average thickness ·25 inch. This is in the state collection.

Another in Dr. Hall's collection is quite as nicely made. The sides are not exactly parallel, as one end is broader than the other; all its outlines are, however, very straight and sharply cut. Its form is rectangular, the length being 3·75 inches, breadth 2·1 inches at one end and 1·85 inches at the other; thickness, which is quite uniform, except just at the ends, which are somewhat thinner, ·25 inch. It is made of a fine, compact, dark purple slate very much like that of which one of the imperforate plates was made. The holes are bevelled from each side though not equally. By far the finest of these two hole stones is one in Mr. Dean's collection; it is of oval form with the ends cut squarely off, and is wrought with admirable skill, the curvature of the sides being very regular and that of both exactly the same; the ends are straight and true and the fiat sides regularly convex. This regularity is more remarkable as the plate is not flat, but twisted slightly, so that its surfaces are spiral, only slightly indeed, but yet very distinctly. It is formed of a very hard, compact clay-ironstone and the twist just mentioned may be due to the cleavage of the mass from which the plate was struck off, but even if this were the case it would, apparently, have been easier to have rubbed the plate flat than to have followed the spiral cleavage, and it is not at all impossible that the twist was intentional on the part of the workman. Its regularity on each side would indicate this, for the stone is not one that would have been found in

thin layers and this plate must have been split from a mass of irregular cleavage, so that its form is by no means certainly due to this. The color of the stone is of a dark reddish-brown and the surface appears to have been originally coated with some black pigment, patches of which still remain, forming spots of smooth, glossy enamel. It is 3·5 inches long, ·5 inch thick near the middle, ·2 inch thick at the ends and 2·5 inches broad in the middle. The holes are bevelled from one side only and are nearly twice as large on that side as on the other, being where largest ·45 inch across.

A large number of perforated plates of stone have been found in the mounds of the west and considerable discussion has arisen concerning them. Schoolcraft figures two which he regards as instruments for twisting sinews or bark into twine, but, as Squier remarks, had this been their use we should expect to find the holes worn by the friction of the twine, whereas no traces of wear are usually visible, the striæ caused by the drill being as distinct as ever. Squier says that he has examined a hundred of different sorts, and in all, the absence of all marks of use was noticeable; he also notices in his "Memoir on Mounds of Mississippi Valley," that in quite a number of stones the holes were almost exactly four-fifths of an inch distant from each other, and on measuring those that I have seen from Swanton, I find that in one case the holes are almost exactly four-fifths of an inch apart and in the other two they vary but slightly from that distance, though, as the holes are not exactly perpendicular to the plane of the stone in all cases, it makes a little difference on which side the measurement is made. This coincidence is remarkable, as the stones described by Squier were from the west, none being from farther east than Ohio. This would indicate that the makers of these objects were particular as to the distance of the holes and that the law they followed was widely known and this is the more interesting on account of the great diversity in the form of the stones. All are thin and flat, but scarcely any two of them agree in outline or size, though not always differing very widely.

Adair mentions a custom existing among some tribes of having high religious dignitaries wear a plate of shell pierced with two holes by which it hung to an otter-skin strap. From this it would seem not improbable that these stones were used as a part of the religious paraphernalia of the ancient people to whom

they belonged, and the absence of marks of wear would seem to indicate that they were worn, not constantly, but only upon special occasions.

A rather rude, but quite unique article is in the state collection. Its general form is that of a long, narrow trapezoid. The ends are rounded and of somewhat unequal breadth. It is made of dark gray mica-schist, thickly studded with small garnets. On one side it is flat and smooth, while on the other it is flat along the central portion, and from this the surface is strongly bevelled to the edges, which are rather thin. The narrower end is thicker than the other. The length of the article is 5·5 inches, breadth at one end 1·3 inches, at the other 1·85 inches, the thickness is, in the centre, from ·5 inch to ·75 inch. As to its use I am unable to conjecture unless for rubbing flesh and fat from skins, or rubbing sinews or bark for twine.

Three articles of somewhat similar form and apparently for the same use were found in different graves. The general form of these is boat-like, one side being flat or nearly so, while the opposite is convex. One of these is of a dark red slate, the base (or top?) is flat, but curved slightly from end to end, while the opposite side is bevelled from the middle where it is thickest to the sides and ends. In the centre of the flat side is a slight groove running nearly from end to end. On each side of the central portion of the object is a hole drilled obliquely from side to side and bevelled from each end. It is pretty well made but less carefully than either of the others. It is 5·3 inches long; ·65 inch high; ·8 inch broad, and the holes are 2·1 inches distant from each other. Of similar material, but of different color, is the second of these objects. It is larger and much more finely finished than the preceding. It is of drab slate with black veins, though much of it is so colored by the red coloring matter already mentioned as to appear reddish-brown; its surface is very smooth and its form regular. The base, or flat side, is rectangular, long and narrow, nearly flat, with but a slightly excavated groove running from near one end to a short distance beyond the middle. The upper surface slopes from the rounded apex to the sides and ends, the side surfaces being slightly convex while the others are flat. Its length is 7·25 inches; breadth in the middle 1 inch, at one end ·85 inch, at the other ·65 inch; height ·75 inch in the middle and ·15 inch at the ends. The holes are bevelled from the flat side and

taper very regularly. The third of these singular objects is equally well wrought; it apparently served the same use, though differing in form from the other two, being much shorter and higher in outline and the slight groove in the others is here represented by a very deep cavity. It is of a delicate green steatite, of very regular form and the surface smooth; this is, however, in some places decomposed and so roughened, the ends are both broken and, it is probable, originally tapered to more or less sharp points. The sides are regularly and quite strongly convex, while the surfaces that go from the apex to the ends are nearly flat. The base is slightly concave over its entire surface, and, as already mentioned, the centre is deeply excavated. This excavation, which is of similar form as the outside of the object, is 2·25 inches long, ·95 inch broad in the middle and ·8 inch deep in the deepest part. From this deepest portion the holes are drilled through to the other side, tapering as they go upwards from ·4 inch to ·25 inch in diameter. From patches here and there of polished surface it would seem that the entire surface was originally well polished, but the material was not sufficiently compact to resist exposure. On one side of the apex is what appears to be the beginning of a third hole. The holes that extend through the stone are 1·1 inch distant from each other on the upper side.

Two carvings, which may be regarded as representations of animals, have been taken from the graves; one of these, shown of full size in fig. 13, is of dark red slate, hard and compact. The surface is very smooth and the curves finely formed. The base, as shown in fig. 13*a*, is flat, oval and pretty regularly cut; it is 3·7 inches long and 1·1 inches broad. Through the base are bored two holes, one at each end; these taper from below upward, from ·4 inch to ·2 in diameter. Continuous with the upper side of the base are the neck and head directed strongly forward; the head is somewhat bird-like in appearance, the eyes are large and very prominent, as shown in fig. 13*b*, which represents the object viewed obliquely, being ·3 inch in diameter at the end and projecting ·2 inch beyond the side of the head, which is straight below, arched strongly above and quite thin, with the end of the beak blunt and rounded; the height of the figure, from the base to the top of the head, is 2·2 inches; length along back, 4·5 inches; length of head 1·4 inch, height 1 inch and thickness ·4 inch. This head was found with the second of the long boat-like objects described above.

Fig. 13*b*.

Fig. 13.

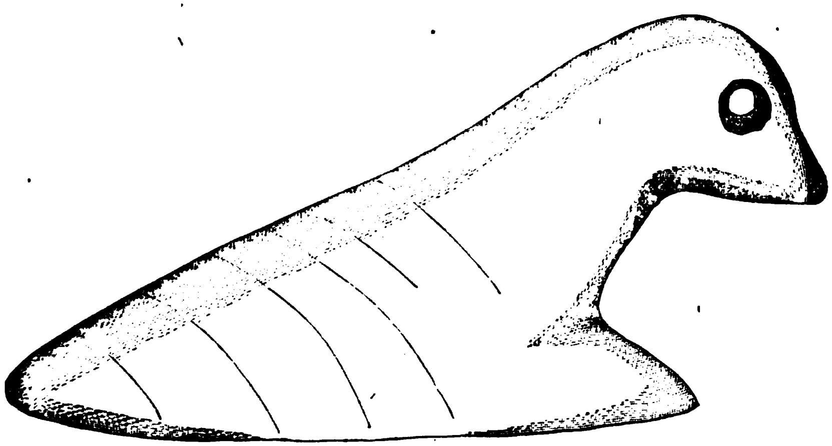
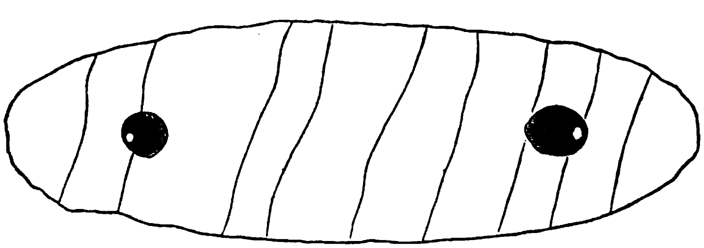


Fig. 13*a*.



CARVING OF DARK RED-SLATE.
Fig. 13, profile; 13*a*, base: full size.
Fig. 13*b*, viewed obliquely from above; about ½ size.

Another of these interesting carvings is in the state collection. This is of pure white marble, finely carved and smoothed, and probably it was originally polished as there is still a slight polish on some portions. Its soft material has suffered more from exposure than the harder rock of which the other head is composed, yet it is in very good preservation. The upper two-thirds are colored a deep reddish-brown while the lower portion is stained bright green; this latter color is probably due to contact with the copper in the graves, but the red color seems to have been applied intentionally. As in the head just described, so in this the eyes are large and prominent, about ·3 inch in diameter at the top and ·17 inch high above the sides of the head. The general outlines of this second head are more angular than those of the preceding, it is broader at the base and the neck is not so long nor so oblique; the end of the nose is, in this, cut off squarely instead of being rounded as in fig. 13, and the sides of the head are nearly straight above and below, while the base is extended somewhat beyond the rest of the figure. The neck is thicker and less regular than that in fig. 13, and on one side are carved grooves which seem as if designed to represent a crest or mane. The base is oval, but much more convex on one side than on the other and it is wider in proportion to the length than that of the preceding; is not perforated as is the other, and its edge is quite undulating. The height of the image is 2·65 inches; length of head 1·5 inches; height of head ·95 inch; height at end of nose ·4 inch; length of base 3·15 inches; breadth of base 1·3 inches in the middle; breadth of neck near the base 2 inches; with this was found the steatite boat-like object described above.

A single example of the discoidal stones which are sometimes found in the west has been found at Swanton and is now in the state collection. Its form is beautifully regular and its surface very nicely finished. The flat sides of the disk are hollowed so as to form shallow cup-like depressions while the edge rounds outwards above and below, but is flat around the middle of the disk. The material of which this discoid stone is made is a compact white quartz, but it is coated over the outside with dark coloring matter, by which its appearance is changed. Its diameter is very nearly three inches, thickness at the edge 1·15 inches; circumference 9·5 inches. The excavated portion does not extend to the extreme edge of the stone, but falls so far short as to leave a narrow rim around the

edge. This rim is rounded very nicely. The diameter of the depressed portion is precisely the same on each side, viz: 2·3 inches, but the depth is ·2 inch on one side and ·15 inch on the other. Squier figures several of these discoid stones, one of which (fig. 121, No. 2) is much like that just described. In Foster's "Prehistoric Races of U. S.," fig. 26 (page 218) is much like this but is perforated through the centre. Squier says that they have been found from the valley of the Ohio River, through Central America to Peru and Chili, and that they have also been found in Denmark. Old writers, such as Adair, mention them as in use for playing certain games at the time they visited the Indians. The writer just named says that they were "made by rubbing them on rocks with prodigious labor," and that they belonged not to individuals but to the tribe, were "kept with religious care" and handed from generation to generation; and were, by law, exempted from the burial with the dead so commonly practised with other implements. This being the case, we may suppose that the presence of one in a grave is indicative of high rank or distinguished service on the part of the person with whose remains it was deposited.

Arrow and spear heads and stone axes are more abundant than other implements in most collections of stone objects, but this is not so much the case with the Swanton collections as usual. Quite a number of these articles have indeed been taken from the graves, but they do not much outnumber other kinds of implements. Arrowpoints are abundantly found on or near the surface all about the town, but the graves have not afforded a large number. It is quite possible that many of those found away from the graves were formed by the same people as those in the graves. The axes are still less numerous for I have seen but five in all. Two of these bore slight notches on each side for the attachment of a handle while the rest were of the sort known as hand axes; all are quite small and well formed, though some are much more neatly finished than others. In none was there any sign of a groove extending around, or on the sides, but only the notches, and these not very deep, on the front and rear edges, so that all may have been easily held in the hand. The three without notches are of the same general form, the lower side, or edge, rounded more or less, the upper straight and thick and the sides straight and inclining towards each other as they approach the top. The form of these is, in general, the same as those figured on page

210 of Dr. Foster's work already mentioned, or figs. 110, page 217, and 112, Nos. 3 and 4, p. 218, of Squier's "Ancient Monuments of Mississippi Valley" (Smithsonian Contributions). One of those from Swanton is quite like Squier's fig. 112, No. 4, both in form and material, and also like a figure in Lubbock's "Prehistoric Times," fig. 164, p. 188, of an axe from Switzerland. The specimen from Swanton is 3·65 inches long, 1·75 inches across the edge, 1 inch across the top, and in greatest thickness ·75 inch. It is most neatly finished of all. The other two straight-sided axes are less regular, the sides are more nearly parallel and they are of larger size, one of them, which is of trap rock, being larger than any other found in the graves; this is 5·75 inches long; 2·2 inches broad at the edge and ·55 inch thick near the middle. The other is of smaller size, being 4·7 inches long and 2·4 inches across the edge. It is of dark colored mica-schist. The two remaining axes, those with notched sides, are both carefully made. The smaller of the two is of trap; the edge is unusually sharp and well shaped and, suitably attached to a handle, it would be regarded, even now, as a by no means useless article. It is 4·2 inches long, 2·65 inches across the edge, 1·23 inches in greatest thickness. The other is nearly as well formed and finished. It is made of a compact purple sandstone and is a little more than five inches long and 2·5 inches across the edge.

The arrow and spear points from the Swanton graves differ somewhat from any others that I have seen, with the exception of one or two. They are thinner than most of those from other localities and are nearly all very regular in form and handsomely finished. The most common forms are the "triangular" and a form which approaches the "leaf-shaped," as nearly as any of the forms under which these articles are grouped, and the "indented." One quite common form is nearly straight across the base, which is thin, the sides curve regularly and gradually towards the point, the base being a little narrower than near the middle. These are not exactly like any that I have seen from other localities. The edges are very sharp and the flakes chipped off in the manufacture of the article were small, so that the surface is quite smooth. They are made of a dark flint and are of different sizes, from 1 inch to 2·5 inches long and from ·75 inch to 1·25 inches broad. A peculiar bluish-white, semi-transparent quartz was used in the manufacture of quite a number of this class of implements. One

of these is much like fig. 103, No. 5, p. 212 of Squier's Memoir and another like No. 9 of the same figure, though broader at the base and indented. Each of these is about 2·25 inches long. Two very long objects for lances, or knives it may be, are of the same material. One of these is much like No. 3, fig. 99, p. 211 of Squier's Memoir. It is 7·25 inches long, 1·8 inches broad in the middle and ·6 inch in average thickness. It is rather bluntly pointed at each end. The other is pointed at only one end and there only very bluntly. It is 9·65 inches long, 1·9 inches broad and in some places nearly one inch in thickness. As may be noticed these last mentioned flints are exceptions to the general rule that the Swanton spear and arrow points are very light and thin. Another object, which may have been used as a lance, or for some other and quite different purpose, is of a similar material. Its form is quite regularly oval, pointed at each end. It is 5·8 inches long and three inches broad in the middle and is quite thin and flat over its sides. Several other large spear or lance heads of good quality, some very finely finished, are in the various collections from the graves we have been considering. These are mostly of dark, greenish flint and are from four to six inches in length. Only two among all that I have seen from this locality are barbed. One of these probably had a stem when first made, but it is now broken off. Its form is broadly triangular, the edges sharp, as is the point, and the short barbs are directed outwards. It is of olive-green flint 1·4 inches long and 1·25 inches broad. The other barbed specimen appears to have been made for a knife, as it is very inequilateral, one side being nearly straight and ending below in a short barb, while the opposite is strongly curved. There is evidence in this, as in the preceding, of a stem. The point is very sharp and the whole very finely made. It is of dark green flint and is little more than two inches long and one inch broad at the broadest part. One of the arrowheads is of the form called by Foster "lozenge-shaped."

So far as I know these forms include all of this class of implements that have been found. Of course all the articles found in the graves are not herein described, but all that are in any way typical that have come to my notice are mentioned so that a tolerably complete exhibit of the contents of the graves is here afforded. My views as to the people who placed the bodies and implements in the graves have already been given.

It is not impossible that more graves will be hereafter discovered and their contents studied, as the locality is probably not exhausted, but at present further examinations cannot be carried on and we can have no further evidence in regard to the character of this ancient people than that afforded by the objects I have attempted to describe. I may add that since the foregoing pages were in type, a fragment of a tube identical in form and material with those described has been found near Burlington, and with it quite a number of arrow and spear points of the same peculiar bluish quartz, of which most of this class of articles from the graves were made.

THE DEVONIAN LIMESTONES IN OHIO. By N. H. WINCHELL, of St. Anthony, Minnesota.

IN Delaware county, in central Ohio, the valleys of the Scioto and Olentangy rivers are excavated mainly in the Devonian. The latter begins in the black slate and the former in the water lime. Thus a connected section of the Devonian limestones may be made out along their banks in the area of a single county.

In the summer of 1872 the writer examined this county with others, for the Geological Survey of Ohio, and found these limestones to consist of the following parts:

1. A hard, fine-grained siliceous limestone, in beds generally of eight to twelve inches, non-fossiliferous or nearly so; of a blue or black-blue color and apt to hold much pyrites. Thickness four to nine feet.

2. A blue and argillaceous limestone in beds usually not exceeding six inches, but sometimes reaching fifteen. This is the principal building stone of Delaware and Erie counties and is extensively wrought at Sandusky and Delaware. The calcareous beds are hard and crystalline, but are apt to be interstratified with thin shaly laminations, injuring their durability. It is quite fossiliferous, holding generally at every quarry *Spirifer mucronatus*, *Cyrtis Hamiltonensis* and *Cyrtoceras undulatum*. It also holds at Dela-

ware a species of *Discina* and at Sandusky a *Tentaculites*. It contains numerous fish remains that have been extensively studied by Dr. Newberry. Its thickness is thirty-five to forty feet.

3. A saccharoidal or often a crinoidal limestone, in beds that weather out three to five inches thick, but in deep quarrying appear a foot or two-thick. This is of a light color and differs constantly in that respect from the last. It is rarely used for any purpose except for quicklime. Its most common fossils are brachiopods, the most conspicuous of which are species of *Strophomena*. It also holds one or two species of Cyathophylloids. *Cyrtoceras undulatum* is also common.

The lower ten feet of this limestone are sometimes quite bituminous, especially when charged with corals, as they not unfrequently are. In the central part of the county of Delaware this belt is chiefly fossiliferous in the lower three or four feet, the remainder being rather hard but of a blue color. The southern part of the same county, however, seems to be without this bluish and highly coralline member, the Delhi beds coming immediately down on to No. 4. This bituminous matter is sometimes in the form of scales and films or irregular patches or pockets, or it is disseminated evenly through the bedding, mingling closely with the sedimentation. In the former case the corals are well preserved. In the latter very few fossils are to be seen, the color of the stone becoming bluish. The thickness of the Delhi beds, including this coralline member, is thirty-eight feet. The corals here found are different species of *Favosites*, *Cœnostroma*, *Stromatopora* and Cyathophylloids.

4. A light-colored, even-bedded, nearly non-fossiliferous, vesicular or compact, magnesian limestone, that is often popularly mistaken for a sandstone. Its upper part, sometimes amounting to ten feet, is in beds of four to six inches and the rest in beds of ten to thirty-six inches. It is even-grained and makes a good cut stone, being considerably wrought for building in several places in northwestern Ohio, as well as for quicklime. Toward the bottom it becomes arenaceous. Its thickness is about twenty-seven feet.

5. An arenaceous limestone like the last, which sometimes is a pure quartzose sandstone and sometimes an arenaceous limestone conglomerate. The water-worn limestone pebbles in this conglomerate are evidently from the underlying limestone (Waterlime) and are occasionally five or six inches in diameter. No fossils have been seen in this member. Thickness two to ten feet.

Notes on the foregoing limestones.

With the exception of the last, these have all been united by Dr. Newberry under the term Corniferous. The last is regarded by him as the equivalent of the Oriskany of New York and the base of the Devonian. Nos. 1 and 2 constitute together a very important and conspicuous member of the Ohio Devonian, which can everywhere be easily distinguished at a glance from the lower members, chiefly by their color, but also by their bedding and by their fossil contents. The uppermost member (No. 1) has not heretofore been distinguished as overlying No. 2. It occurs in the Olentangy River near Waldo in Marion county, and near Norton in Delaware county. It may also be seen in the bed of the same river at Delaware, where it is overlain by the blue shale that has been regarded as the representative of the Hamilton.* It also is seen in the Anglaize River south of Defiance, in Defiance county, and in the Maumee near the line separating Henry from Defiance county, where it is immediately overlain by the black slate, the "blue shale" being entirely wanting. A bivalve impression, two inches in diameter, resembling *Aviculopecten*, was seen in it at Delaware. This limestone is believed to be the equivalent of the Tully Limestone of New York. No. 2 is the limestone that has been described as Hamilton in the state of Michigan, or perhaps more correctly it is the upper portion of that limestone. It has there not been separated from the Corniferous. Hamilton fossils prevail over those having a distinctive Corniferous character, both in Michigan† and in Ohio throughout this blue limestone, and in Michigan seem to extend downward into the Corniferous. The shales, however, which accompany this limestone in Michigan are wanting in Ohio. There is a fossiliferous black shale in northern Michigan which, however, may be the equivalent of the Marcellus. The writer, in deference to Dr. Newberry's nomenclature, has distinguished No. 2, in reporting on several counties in Ohio, as Upper Corniferous. It is believed to be the equivalent of the Hamilton of New York. It is colored on the Ohio county maps as "Corniferous," that color also covering, as already remarked of the word, Nos. 3 and 4, the narrow blue belt representing the shale overlying No. 1, which the writer has distinguished as Olentangy Shale.

*See Report of Progress on the Ohio Survey for 1869.

†See Report on the Grand Traverse Region, by A. Winchell.

No. 3 seems in fossil contents, as well as in thickness and geological position, to be the exact equivalent of the Corniferous Limestone of New York. The writer, to distinguish it from other portions of the great Corniferous Group of Dr. Newberry, has designated it Delhi Limestone, from the village of that name in Delaware county where it is extensively burned for quicklime.

No. 4 in like manner represents the Onondaga Limestone of New York, and in a similar manner furnishes a good building stone. It is the lower portion of this member that has been referred to as representing the Ohio corniferous, quarried at Charloe, Paulding county. It may be seen in the banks of the Scioto near Bellepoint, in Delaware county, and is burned for lime at Bellevue in Sandusky county. Its manner of union with No. 5 is not constant. Sometimes it is not at all sandy near the bottom, and at other times it contains one or two very sandy layers, before the sandy character of No. 5 is fully set in.

That the shale which overlies the foregoing No. 1, and which is well exposed in the Olentangy River at Delaware, is not the Hamilton of New York, is evident from the following considerations:

1st. At every point examined it is found to be closely interstratified with the black slate, even to the base; and in Defiance county it is entirely wanting, the black slate lying on No. 1. This indicates that its associations are with the black slate rather than with the Hamilton.

2d. If it be the Hamilton, in Defiance county, the Hamilton is wanting; yet there are Hamilton fossils in the blue limestone lying below (No. 2).

3d. It has not yet afforded to the writer a single fossil form. The fossils at Prout's Station cannot come from the same shale, although the writer has not examined that locality. A very close inspection of this shale in Delaware county, where it affords continuous bluffs, sometimes for half a mile, has not disclosed a single fossil.

4th. It *does not graduate* into the underlying blue limestone (Nos. 1 and 2) but the transition is abrupt, from soft, argillaceo-bituminous shale in thin beds, to a hard siliceous limestone in heavy beds.

5th. While it contains no fossils proving its Hamilton age, there are fossils in No. 2 that are confessedly of Hamilton age, and those fossils are formed through the whole thickness of No. 2.

6th. In New York the Hamilton is shaly and calcareous; all other formations in passing west into Ohio change from coarse sediment to fine. Coarse sandstones become shales. Shales become limestones and limestones lose much of their thickness. In accordance with this well-known law it is more likely that a calcareo-argillaceous formation should become calcareous like No. 2 than entirely argillaceous or bitumino-argillaceous, like the Olentangy Shale.

If the foregoing parallelizations are correct it does not seem that the Hamilton runs out in passing through Ohio, but maintains a full development as a calcareous member of the Devonian.

ORIGIN AND PROPERTIES OF THE DIAMOND. By A. C. HAMLIN, of Bangor, Me.

THE formation of the diamond is the same, with slight exceptions, all over the world, and the true matrix of the gem is in the gravel beds of the Tertiary period.

This peculiar formation in which the diamond is always found unless the strata has been disturbed by currents of water, is a ferruginous conglomerate, and known as *cascalho-mellan* or hard-pan. It is forming even at the present day, and examples may be seen in the "Allios" of France, the conglomerates of Cape de Verde, or the coasts of Cornwall, and in many other places. The diamond placers are situated at the bottoms of ancient shallow lagoons or lakes, and the deposits may be traced oftentimes with perfect regularity from the shallows of the shore of the lake along its depths to the opposite side. The gems found here have unbroken edges, and show no signs of aqueous action, while those obtained from the beds of rivers which have traversed the diamond placers, plainly indicate abrasion occasioned by the force of falling water.

The keen eye of Buffon early detected the formation of the true gem strata, and believing that the gems were produced in these peculiar beds by the solar forces, he boldly asserted that they were formed in the superficial strata from *débris* of older formations

mineral, animal and vegetable. There are many evidences to sustain the view of diamonds having been deposited where they are found, such as the tints of the diamond corresponding to the color of the surrounding earth, the impression of clay or grains of sand on the sides of the crystals, etc.

It has been admitted by eminent mineralogists, that the diamond proceeded from the slow decomposition of vegetable material and even animal matter, as the requisite carbon could be obtained from either source. But they have also maintained that the gem was found under the same condition of heat as produced the metamorphism of argillaceous and arenaceous schists: these being supposed to have once been altered from shales impregnated with carbonaceous substances of organic origin. To this theory, however, the microscope offers decided objections, for it reveals within the diamond, vegetable fibres and germs of higher organization, which fact forbids the idea of the development of any considerable degree of caloric. The quantity of vegetable remains often found in the diamond is considerable, and the stone is admitted by microscopists to be the foulest of gems, cavities having been found in the mineral which have yielded impurities like rotten weeds.

Admitting the hypothesis that the diamond is found in its matrix at the bottoms of these ancient lagoons, and that it is composed of carbon, we have abundant material for the formation of the gem in the vegetable and animal matter, which is collected by the impervious conglomerates forming the beds of stagnant pools. Carbonic acid is readily produced from the decomposition of this organic *débris*, and is, moreover, constantly evolved from the earth itself. It has the property of decomposing many of the hardest rocks and is the cause of that mysterious decay which Dolomieu called "*la maladie du granite.*"

It is not at all improbable that the diamond contains hydrogen as some *savants* have suspected from the energy of its refractive powers. In carburetted hydrogen we have the united force of two of the most active substances known as organogens or generators of organic bodies; and the ease with which their combinations may be decomposed by electricity, also the extraordinary display of electric force, along the true gem fields, are to be considered in the study of this subject. The production of a drop of water, by the action of electricity upon a mixture of hydrogen and atmospheric oxygen, suggests the manner in which the diamond might

be formed from carburetted hydrogen. It is true this experiment in the laboratory has failed to produce the transparent and crystalline form of carbon, although it has thrown down the element in an amorphous state. This failure is by no means decisive, for many of the simple acts of nature are beyond the imitative power of man.

The charm of the diamond consists not only in the extraordinary brilliancy of the stone, but especially in the display of prismatic color. The cause of these two properties has been a theme of earnest study among experimentalists, and many ingenious theories have been offered. The brilliancy appears to be due to the nature of the substance, and not especially to its hardness or its density. The soft minerals crocoite, greenockite and octahedrite, which exceed the diamond in refractive power, indicate that hardness has nothing to do with brilliancy. And if this property is in any way connected with the density of a mineral, the zircon, the sapphire and the spinel, ought to exceed the diamond in their refractions, but in fact they are far inferior.

The topaz, which has the same specific gravity as the diamond, has a refractive index of but little over one-half that of the diamond. Concerning the charming prismatic display many plausible theories have been offered, and none, perhaps, so probable as that lately advanced by an English philosopher. This *savant* adopted the view that this property was due to the relation of the low dispersive to the high refractive power of the gem, and hence the *Spinelle* does not exhibit the rainbow hue because it possesses a very high refractive. As the diamond stands quite alone among the gems in this relationship, it has been extremely difficult to find transparent minerals to test the correctness of the theory. The white garnet would furnish a fine example if we could find a transparent specimen, as it possesses a refractive of 1·81 and a low dispersive of ·033. But unfortunately gems of this variety are quite unknown. However, Mt. Mica, with its white tourmalines has furnished us with a perfect test for the hypothesis. This gem affords the same relationship as the diamond, having a refractive of 1·66 with the remarkably low dispersive of ·028 while the diamond has a refractive of 2·24 with a dispersive of ·038. Therefore if the theory is correct the white tourmaline should exhibit the colored reflections as well as the diamond; but on cutting several of these stones into fine and perfect brilliants we fail to wit-

ness any prismatic display. Therefore we are reluctantly compelled to regard the ingenious calculation as incorrect.

The diamond is not the most ancient of gems, and it was not until the art of man polished its surface and revealed its hidden splendors, that it became a favorite stone with man. The process of polishing is not of very ancient date, but it extends many centuries beyond the discoveries of Louis de Berquem.

In early times diamonds were so rare that only princes possessed them, and the smallness of the size of those that have descended to us from those periods indicates that the paragons were unknown before the fifteenth century. History sustains this view, and the celebrated traveller, Tavernier, boldly asserts that all of the famous diamonds have been discovered since the above mentioned date. The gem was but little known in Pliny's time, and it does not appear in the decorations of the fêtes of Alexander, and the early conquests.

The color suite of the diamond is far more extensive than has been generally admitted. Of the yellow tint it affords the most beautiful examples, and far surpasses in variety all the other gems. To the yellow topaz it is decidedly superior in its range of shades, and in some of its chrome-like tints it is without an equal among the gems. Fine green are sometimes seen, but the ruby red is exceedingly rare. Those of a peach blossom hue are not uncommon and there are recorded a number of diamonds exhibiting a beautiful shade of blue. The nodular or globular forms which are apparently water-worn are really natural crystals, the crystallization radiating from the centre. As they are deficient in cleavage planes it is quite impossible to polish them, which fact is sufficient to distinguish them from the water-worn pebbles. They recall to mind the singular concretionary and radiated masses of the animal remains found in the Old Red Sandstone.

The diamond is widely distributed over the earth. The gem fields of Asia and Brazil are very extensive, and the placers of Africa are not only exceedingly rich but they are of enormous extent, and will probably supply the wants of commerce for ages to come. Its geological age is certainly very recent if we admit its matrix to be the secondary gravel beds of the Tertiary period.

Furthermore, if we accept the observations of Humboldt, Murchison and Verneuil, concerning the deposition of the bones of the

rhinoceros and the mammoth, in strata twenty feet below that in which the diamond is found in the Adelfskoi district of Siberia, we must reasonably conclude that the mineral was deposited since the introduction of animal life, and that it is also the last gem placed upon the earth.

ON SOME EXTINCT TYPES OF HORNED PERISSODACTYLES. By EDWARD D. COPE, of Philadelphia, Penn.

IT is well known that the type of *Mammalia* of the present period, which is preëminently characterized by the presence of osseous horns, is that of the *Artiodactyla ruminantia*. At the meeting of the Association of last year, held at Dubuque, I announced that the horned mammals of our Eocene period were most nearly allied to the Proboscidians. I now wish to record the fact, as I believe for the first time, that the Perissodactyles of the intermediate formation of the Miocene embraced several genera and species of horned giants not very unlike the *Eobasileus* and *Uintatherium* in their armature.

While exploring in connection with the United States Geological Survey of the Territories, I discovered a deposit of the remains of numerous individuals of the above character, which included among other portions crania in a good state of preservation. Most of these skulls are nearly or quite three feet in length, and mostly deprived of their mandibular portions; these are quite abundant in a separated condition. The crania represent at least six species, while the mandible represents a condition distinct from that of *Titanotherium* or any allied genus, viz.: I., 0; C., 1; P. M., 3; M., 3. The teeth diminish rapidly in size anteriorly, and there is no diastema behind the canines, whose conic crowns do not exceed those of the premolars in length. To the genus and species thus characterized I have elsewhere given the name of *Symborodon torvus*.

One of the crania, referred to under the name of *Miobasileus ophryas*, is characterized by its strong and convex nasal bones

and concave superior outline posteriorly, and by the presence of a massive horn-core on each side of the front, whose outer face is continuous with the inner wall of the orbit, as in the *Loxolophodon cornutus.* It stood above the eye in life, and diverged from its fellow so as to overhang it. In the specimen, which was fully adult, they were worn obtuse by use — length, about eight inches; thickness, three inches. The molar teeth differ from those of *Titanotherium Proutii* in having cross crests extending inward from the apices of the outer chevrons, each of which dilates into a T-shape near the cones.

The third species is referred to the new genus *Symborodon* under the name of *S. acer.* It has overhanging eyebrows and the vertex little concave; but the nasal bones are greatly strengthened, and support on each side near the apex a large curved horn-core of ten inches in length with sharply compressed apex. These horns diverge with an outward and backward curve, and when covered with their sheaths must have considerably exceeded a foot in length. This was a truly formidable monster, considerably exceeding the Indian rhinoceros in size.

The fourth species is allied to the last, and has well developed superciliary crests without horns. The latter are situated well anteriorly, and are short tubercles not more than three inches in height. They are directed outward and have a truncate extremity. The type individual is of rather larger size than those of the other species. There are several crania referrible to the three now named. The present one has been named *Symborodon helocerus.*

Other species based upon crania without mandibles, were referred to the genus *Symborodon.*

These animals show true characters of the *Perissodactyla* in their deeply excavated palate, solid odontoid process, third trochanter of femur, which has also a pit for the round ligament, in the divided superior ginglymus of the astragalus, etc.

On the Origin of Insects and Remarks on the Antennal Characters in the Butterflies and Moths. By Aug. R. Grote, of Buffalo, N. Y.

We understand metamorphosis in insects as correlated with development, and as a growth period characterizing the gradual escape from a lower and more embryonic physical condition. We may consider it as a reminiscent action marking the successive developmental halts in the kingdom of Articulata. And, in reasoning upon the facts brought to light by the embryological studies of Haeckel, Fritz Müller, Packard and Dohrn, we must accept the conclusion that the common origin of Tracheata is to be sought in the biregional Crustacean. The fact of the abortion of the tracheal system in the thorax presents a parallel to the fact of the remains of the swimming bladder in man. In considering the general progression of Hexapoda, the Devonian and earliest forms known seem to be Neuropterous, nor is there yet sufficient evidence to prove that the common origin of Hexapoda is to be carried back through suborders exclusively fossil. Yet that the position of the Neuroptera suggests such a third, less distinctively marked series, which is now no longer living, and which has given rise to the Orthoptera, Hemiptera and Coleoptera, and again to the Diptera, Lepidoptera and Hymenoptera, cannot be denied. And that the Lepidoptera are the more recent, palæontological evidence seems to confirm, while we should not expect the Butterflies among the flowerless forests of the Carboniferous period. As yet the fossil butterflies discovered, such as those recently described by Mr. Scudder, belong to the Miocene Tertiary. As matters now stand there can be no objection to the conclusion that the Butterflies and Bees are contemporary with man. Thus hitherto recorded observations suggest to us very plainly the direction from which the hexapodous type has proceeded. The land was probably visited at first irregularly and then at a stated life-period, while the hexapodous type affords an ascending series of grade in terrestrial adaptation. The consideration of the general longer period of larval life shows a connection with this effort, while the greater equalization in duration of the periods of growth, or the curtailment of the younger stage to the benefit of the adult, marks a permanent advance in type in Hexapoda.

The antennal structure in the Butterflies and Moths has been

made the basis for classification, at different times, by two French entomologists, MM. Duméril and Boisduval. While the terms employed by the former have priority, those of *Rhopalocera* (club-horned) and *Heterocera* (diversely-horned), used by the latter, have come into general use, chiefly through the bibliographical importance of the work, the first volume of the uncompleted Spécies Général (the completion of which is now no longer a necessity), in which they were announced. The increase in our knowledge of the Lepidoptera has brought with it a different conception of the antennal structure and abundant physical proof of the absence of any such an absolute difference. The divisional values intended are unequal. The terms are inapposite and should be rejected from scientific use and literature. On reflective observation the difference between the antennæ in the Butterflies and Moths does not seem to me to lie in the characters of their different terminations but in the upward direction, comparative rigidity and uniformity in length of the antennal stem in the Butterflies. The flexibility and diversity of the appendages to the joints of the antennal stem in the Moths point to a more active use, while the more lateral and forward direction is a lower character in grade. From the stout, rayed and short antennæ of *Attacus*, to the thread-like neuropteriform and lengthy antennæ of *Adela*, there is a wide diversity indicative of utilitarian change. When we remember the general habit of the Moths, the necessity for a development of their perceptive faculties, independent of vision, seems obvious; their more sensitive antennæ may protect them from many enemies to which their habit exposes them. On the other hand the Butterflies are more protected by vision; and the rigidity, together with the greater uniformity in length of the antennæ, seems to be the result of desuetude. In the *Hesperidæ*, a group occupying an intermediate station in rank and, I believe, in time, there is a greater comparative diversity in the length of the antennæ as compared with the true Butterflies. In *Castnia* and the higher Moths the antenna is, as we naturally expect it, butterfly-like in structure.

This change in the antennal structure in the Lepidoptera accompanies the change in the position of the wings, signalized by Agassiz in 1849, the discovery of which, on the whole, may be considered as our most important accession to an understanding of rank within the Lepidoptera. Agassiz's observations are con-

fined to a comparison of the quiescent positions of the wings. In the act of assuming flight a single muscular action seems necessary to the Butterfly. The Moth throws the deflexed wings first forward, unfolding the secondary in a horizontal direction (not unplaiting it as in the lower suborders); under the same circumstances the Hesperian first elevates the horizontally extended hind wing.

I notice, in conclusion, Dr. Clemens' experiment with the moth *Platysamia cecropia.* Concomitant with the gradual excision of the antennæ, Dr. Clemens found a corresponding indisposition to flight presented by the mutilated insect. At last "the power of hovering was completely lost," and Dr. Clemens drew the extraordinary conclusion, that "the antennæ are instruments of atmospheric palpation." The power of hovering, on the contrary, was not lost by antennal mutilation, but became suspended through the consequent loss of the perceptive faculties of direction, and the nightflying moth naturally refused to proceed. The use and control over the wings, through the thoracic muscles, could not have been impaired by the loss of the antennæ.

THE LARGEST FOSSIL ELEPHANT TOOTH YET DESCRIBED. By EDMUND O. HOVEY, of Crawfordsville, Indiana.

ABSTRACT.

THIS tooth was found in Alameda Co., California, and is now in the Cabinet of Wabash College, Indiana.

Its vertical depth is thirteen (13) inches, transverse measurement is fifteen (15) inches, length of triturating surface nine (9) inches, and the weight of the tooth is twenty-one and a half pounds avoirdupois.

Notes on the Geology and Economic Mineralogy of the Southeastern Appalachians. By T. Sterry Hunt, of Boston, Mass.

ABSTRACT.

The author began by a brief sketch of the physical geography and topography of the mountain region which borders, on the southeast side, the great Appalachian valley in its extension from southwestern Virginia to northern Georgia, and referred to the published accounts of Henry Darwin Rogers and Professor Guyot, who are our best authorities on this region. He described the bifurcation of the mountain chain of crystalline rocks to the southwest of Lynchburg, the eastern branch of which retains the name of the Blue Ridge, and the western is known as the Iron Mountain, Smoky Mountain, or Unaka range; the two ridges inclosing an elevated valley, in the northern part of which the New River takes its rise. The prevalence over large portions of this region of gneisses and mica-schists like those of the White Mountains was noticed, and the character presented by their superficial decay described. The drift-phenomena of the North are here unknown, and the rocks, decomposed to great depths, still retain their original positions. The inclined beds are to be seen in the cuttings through soft clays, which were once nearly vertical strata of hard feldspathic and hornblendic rocks. This change was chemical, and not mechanical, and was due to the action of water holding in solution carbonic acid and oxygen, which had removed alkalies and lime, and peroxidized the iron. The existence of similar phenomena in Brazil and other countries was noticed, and it was shown that it appears only in regions beyond the limits of glacial action. The question was then asked why do the similar rocks in New England offer no evidences of such a decay, and it was suggested that it was the result of a process which took place at a very remote period, and before the glacial erosion, which has, in the regions to the northeast, removed all traces of these softened and disintegrated rocks. The author, while maintaining this view, desired to call especial attention to this curious and important geological phenomenon, which he connects with climatic and atmospheric conditions unlike those of the present period.

The concretionary veins of these gneissic and micaceous rocks

were next noticed. Some of them are made up of coarsely crystalline orthoclase with quartz, tourmaline and great plates of mica, while in others examined by the speaker, calcareous spar and calcareo-magnesian silicates such as hornblende and pyroxene, with zoisite and garnet, are met with. These minerals are often associated with sulphurets such as pyrite, pyrrhotine, chalcopyrite, and more rarely with galena, blende and molybdenite. The character of some great deposits of iron and copper sulphurets, met with under similar conditions from Virginia to Tennessee, was described; some of them are clearly transverse veins, but others, which seem intercalated in the stratification, exhibit in the banded arrangement of their materials, and in the grouping of their crystalline minerals, evidences that they are, not less than the transverse veins, the result of concretionary deposition in rifts in the strata. Some phenomena of infiltration in the laminæ of the adjacent schists were described; but it was contended that these are but local and accidental phenomena, and are not to be confounded with the deposits of sulphurets which in the Huronian rocks of the Green Mountains and elsewhere seem to have constituted from the first a portion of the formation.

The economic value of these great metalliferous lodes of the southeastern Appalachians was alluded to. The copper mines of Ducktown, in Polk County, Tennessee, and of the Ore Knob, in Ashe County, North Carolina, were noticed, and the value of these and of similar deposits in Virginia, as sources both of copper and of sulphur, was pointed out. While England brings from South Carolina our phosphates for the manufacture of fertilizers, she imports from Spain the sulphuret of iron to furnish the acid necessary for their treatment. We, on the contrary, bring the native sulphur from Sicily for the same purpose, while the mountains of the Blue Ridge contain deposits of sulphur-ore as abundant as those of Spain, which will one day be made available for the treatment of the South Carolina phosphates, and their conversion into the fertilizers so necessary for southern agriculture.

Prof. C. A. White, in support of these views, described the evidences of a similar profound disintegration of the crystalline rocks in the northwest, and stated that from such a decomposed material a great part of the soils of the region was formed. He was of the opinion that it had taken place previous to the Cretaceous period, since the strata of that time in the region in

question were formed from the results of this decay of the feldspathic and hornblendic rocks of the vicinity.

THE METAMORPHISM OF ROCKS. By T. STERRY HUNT, of Boston, Mass.

ABSTRACT.

THE various changes which rocks undergo under the influence of water, air and various gases, and their changes in molecular structure, were briefly noticed, and the use of the name of metamorphic rocks, as now generally applied to crystalline strata, considered. While some geologists have considered that many of these, such as gneisses, diorites, serpentines, talcose and chloritic rocks were igneous products, more or less modified by subsequent chemical processes, others maintained that they were formed by aqueous sedimentation, and subsequently crystallized. This was taught by Hutton; and when, early in this century, the crystalline rocks of the Alps were shown to rest upon uncrystalline fossiliferous strata, it was suggested that the overlying crystallines were newer rocks, which had undergone a metamorphism from which those directly beneath had been exempted. This notion spread until the great crystalline centre of the Alps was considered to be in part of secondary and even of tertiary age. The history of the extension of this notion to Germany, to the British Islands, and to New England was then sketched, and it was shown that similar crystalline rocks from supposed stratigraphical evidence came to be referred to formations of very different ages in palæozoic or more recent geologic times.

The author then detailed the course of study by which he had been led to question this notion; he showed that there was, according to Favre, no longer any evidence in the Alps in support of the view above noticed; that Sedgwick in England, and Nicoll in Scotland, had rejected the notion of the palæozoic age of the crystalline schists in these countries, regarded by Murchison as Cambrian and Silurian; and finally gave the observations by which he (the speaker) had satisfied himself that the crystalline rocks of

the Green Mountains and the White Mountains, and their representatives alike in Quebec, New Brunswick and in the Blue Ridge were more ancient than the oldest Cambrian or primordial fossiliferous strata. He showed how folding, inversion and faults had alike in the Alps and in Scotland led to the notion that these crystalline rocks were in many cases newer than the adjacent fossiliferous strata, and mentioned that the subject would be further illustrated by a paper on the geology of New Brunswick.

NOTE.—In a paper on the geology of the White Mountains in the Proceedings of the A. A. A. S. for 1872, Prof. C. H. Hitchcock (p. 146) refers to my address before the Association in 1871, in which I have discussed the crystalline rocks of New England, and speaks of "the position assigned by Dr. Hunt to the whole White Mountain series in his * * * address." According to him I have referred "the age of the series to the *Cambrian*, not far from the period of the Potsdam sandstone." This is however completely at variance with the statements of my address, and with my whole argument extending over several pages. I have there stated with regard to certain crystalline schists of Europe, my conviction that they "*belong to a period anterior to the deposition of the Cambrian sediments, and will correspond with the newer gneissic series of our Appalachian region*," that is the White Mountain series (p. 32). Again (p. 36) I consider the view which I formerly shared with most other geologists of the palæozoic age of the "*crystalline rocks of the Green Mountain and White Mountain series*," and declare that "I find on a careful examination of the evidence no satisfactory proof of such an age and origin, but an array of facts which appear to me incompatible with the hitherto received view and lead me to conclude that *the whole of our crystalline schists of eastern North America are not only pre-Silurian but pre-Cambrian in age*." This view is, I believe, adopted by Prof. Hitchcock. He in his paper farther states his opinion that the lower part of the White Mountain series is Laurentian, but as my definition of the White Mountain series in the address above quoted is primarily lithological and expressly excludes the rocks of the Laurentian series, the statement of Prof. H. amounts only to an assertion that the White Mountain series in certain parts of New Hampshire rests directly upon Laurentian rocks, which is by no means improbable. I pointed out in 1870 and 1871 reasons for supposing the existence of areas of Laurentian strata both in eastern and western Massachusetts.

GEOLOGY OF SOUTHERN NEW BRUNSWICK. By T. STERRY HUNT, of Boston, Mass.

ABSTRACT.

THE recent labors under the Geological Survey of Canada by Messrs. Bailey, Matthew and the author were sketched. They show south and west of the New Brunswick coal-basin various uncrystalline formations, all resting upon ancient crystalline rocks. These latter are by the author regarded as for the most part the

equivalents of the Green Mountain and the White Mountain series, or what he calls Huronian and Montalban. These are penetrated by granites, and associated in one part with Norian rocks, but the presence of Laurentian in the region is somewhat doubtful. While the author recognizes thus, at least, four distinct series of pre-Cambrian crystalline rocks in eastern North America, he does not question the possible existence of yet other series in this region. The analogies offered by the more recent rocks of this region are very suggestive. We have within twenty miles of St. John, New Brunswick, larger or smaller areas of not less than five palæozoic formations, the Menevian of Lower Cambrian age, the fauna of which has been so well studied by Hartt; true Silurian, probably of Lower Helderberg age; Devonian, yielding the fossil flora made known to us by Dawson; Lower Carboniferous, and true Coal Measures, besides sandstones of Mesozoic age. Each one of these is found resting on the older crystallines, and except the last they are highly inclined and even vertical. As the result of contortions and overturn-dips, the older crystalline strata are found to overlie in some cases the newer ones; besides which the latter are occasionally formed in great part of the ruins of the crystalline strata, and so consolidated that they have been confounded with them. Recomposed rocks made up of the débris of pre-Cambrian felsites and orthophyres are found alike in the Lower Carboniferous and the Silurian series, and the beds of the latter are made up in other localities of comminuted Huronian diorites and argillites. A conglomerate of similar origin occurs at the base of Menevian or Lower Cambrian, and other parts of this series abound in the ruins of the White Mountain mica-schists.

BREAKS IN THE AMERICAN PALÆOZOIC SERIES. By T. STERRY HUNT, of Boston, Mass.

ABSTRACT.

THE author began by considerations on the value and significance of breaks in the succession of strata and of organic remains. He then referred to the classification of the palæozoic rocks of the New York series, and showed that Hall, in 1842, and

again in 1847, pointed out the existence therein of a fauna older than what was then called Silurian by Murchison, or was known in Great Britain; Hall maintaining that our comparison with British rocks must commence with the Trenton limestone, the equivalent of the Upper Cambrian of Sedgwick (Llandeilo or Lower Silurian of Murchison). The rocks below this horizon in America are the equivalents of the Lower and Middle Cambrian of Sedgwick, which, when they were found to be fossiliferous, were wrongly claimed by Murchison as part of the Silurian.

He sketched the history of the introduction of the nomenclature of Murchison into our American geology, and then proceeded to show the existence of a break both stratigraphical and palæontological at the base of the Trenton. The contact between the Calciferous sandrock and the unconformably overlying Trenton is seen in Herkimer County, N. Y., according to Hall. The so-called fossiliferous Quebec group of Logan, the Primal and Auroral of Rogers, which extends along the great Appalachian valley from the Lower St. Lawrence to Georgia, corresponds to the Lower and Middle Cambrian; and the Potsdam, Calciferous and Chazy formations are its equivalents in the valleys of the Ottawa and Lake Champlain, much reduced in thickness. These are overlaid by the rocks of the Trenton and Hudson-River groups (Upper Cambrian), which in various localities to the north overlap the older fossiliferous rocks, and in the absence of the latter, repose directly upon the crystallines, indicating a considerable continental movement corresponding to the break in palæontological succession.

The relation between these is explained by Logan as resulting from a movement posterior to the deposition of the Hudson-River group, which produced a great uplift of several thousand feet, extending for more than one thousand miles. While showing that there have been movements in parts of the region since that period, the author rejects the above explanation, and shows that the relation between the two is due to the fact that the Trenton and the Hudson-River rocks overlie unconformably the disturbed Quebec group. These two great discordant series correspond to the rocks of the first and second faunas of Barrande.

The second great break is at the summit of the Hudson-River group, and is marked by the Oneida conglomerate in New York, and a similar one in Ohio described by Newberry. The rocks above, to the base of the Corniferous limestone in the New York

series, are the Upper Silurian of Murchison, or Silurian proper, and hold what is called by Barrande the third fauna. As long since shown by Hall, they are, however, to be divided on palæontological grounds into two groups, the lower including the Medina, Clinton and Niagara formations, and the upper what was named the Lower Helderberg group. These are separated in New York and Ontario by the great non-fossiliferous Onondaga group, holding salt and gypsum, and deposited from a great salt lake.

The close of the Onondaga was marked by another period of disturbance, which, like that preceding the deposition of the Trenton, changed the levels, and caused the ocean-waters to spread alike over the Onondaga formation and the adjacent rocks which had formed the ancient sea-barrier. Then was deposited the Lower Helderberg limestone, followed by the Oriskany sandstone, together constituting a fourth natural division of our palæozoic rocks. This limestone was deposited unconformably over the Trenton and Hudson-River rocks in the St. Lawrence valley, and upon the older crystallines in various localities among the Appalachian hills in New England and the British Provinces. Over this whole region there are no known representatives of the second, and, except to the far eastward, none of the third or Medina-Niagara fauna. The fourth or highest Silurian fauna corresponds to the Ludlow rocks of Britain, or the Upper Silurian of the Canada Survey; while to the third fauna this survey has applied the name of Middle Silurian. The necessity for such a division, in accordance with the views of Hall, is admitted, but the name is to be rejected, since the rocks immediately below it are properly not Lower Silurian but Upper Cambrian.

Evidences of a fourth break between the Oriskany and the Corniferous were mentioned in the erosion of the former in New York and Ontario, although to the eastward, in Gaspé, they form a continuous series. The author closed by a tribute to the memory of the venerable Sedgwick, the Nestor of British geologists, who died last winter; and to the labors of Prof. James Hall, who, in his vast work on our palæozoic geology, has reared for himself an imperishable monument.

NOTE.—An unpublished geological map of northeastern America, extending from Labrador to the Mississippi and to Virginia, prepared by the author so as to show by as many different colors the geographical distribution of the rocks of the four palæozoic faunas recognized in the above paper, was exhibited by him to the geological members of the Association.

Geological History of Winnipiseogee Lake. By C. H. Hitchcock, of Hanover, N. H.

The hydrographic basin of Winnipiseogee Lake comprises about three hundred and fifty square miles. Its waters flow into the Merrimac, though the general level of the country would seem to ally it with the waters of the Saco or Cocheco valley.

The lake is quite irregular in form. Its general course is from S. 25°–30° E., with several long bays or arms. On the south is Alton Bay, eight or ten miles long, which resembles a fiord more than any of the other arms. On the southeast is Wolfsboro Bay in close connection with Smith's Pond. On the northeast are two branches into Moultonboro. On the northwest is the expanse known as Meredith Bay. The western shore is comparatively straight from Meredith village to Alton Bay village. The hills about the lake are steeper than the average in other parts of the state.

The length of the lake proper is nineteen miles. The breadth at the widest part is eight and one-fourth miles. The area of the water is sixty-nine square miles, five hundred and thirty-one acres and 3·03 square rods. If Long Bay, which is properly an expansion of the outlet, be added, the area becomes seventy-one square miles, five hundred and fifty-nine acres and 43·56 square rods.

The lake abounds in islands. Their number, large and small together, is two hundred and seventy-four. The height above mean tide-water is given by the best authorities at five hundred and one feet. The water is remarkably pure but shallow. No soundings have been made, but no part is likely to be over two hundred feet deep.

Commencing at the outlet, passing northerly around the hydrographic basin, the following may represent the altitudes of the rim above the lake. We quickly reach a hill about two hundred and seventy-five feet, then descend a hundred feet and, with other irregularities, reach Wadleigh Hill, three hundred and sixty feet. At the north foot of Wadleigh Hill lies Meredith village, which is also at the end of the northwest arm of the lake. The lowland continues six or eight miles to the summit on B. C. and M. R. R. towards Ashland, one hundred fifty-three feet, passing over a body of water called formerly Measly Pond and latterly Waukewan

Lake. The hills on the west side of Waukewan rise four hundred feet or more above the main lake.

Passing to Sandwich through Centre Harbor, the rim lies between Lake Squam and the tributaries of Winnipiseogee. The lowest point in Centre Harbor is one hundred and sixty feet, in a depression about the centre of the township. Between Long Pond and Squam, the height cannot be more than about forty feet. The lowest point in the rim of the basin is here. Squam Lake is about one-third the size of Winnipiseogee, and flows into Little Squam Lake, and thence about three miles, through a narrow tortuous valley with steep sides, to the Pemigewasset River at Ashland. Between Squam Lake and Ossipee Mountains the country is low, with a few small ponds lying in hollows of the drift. The lowest point I can find is in Sandwich, two hundred and nineteen feet, and scarcely any hill in the low country to the east, towards Saco River, will rise to four hundred feet above the lake.

Passing south the Ossipee Mountains succeed, attaining an altitude of at least fifteen hundred feet. To the south the two lowest points are at the crossing of the divide by the Wolfsboro branch railroad, say two hundred and fifty feet, and the ridge leading to Merrymeeting Lake, which is about the same. The steep hill east of Alton Bay is four hundred and forty-seven feet above the lake. The height of the divide between Alton Bay and the waters of the Cocheco River is only seventy-two feet; the west side of the Alton Bay valley is from seven hundred to eight hundred feet above the lake or six hundred and twenty-seven at the lowest point. Passing northerly succeed the mountains of the Belknap range, the highest attaining an altitude of one thousand nine hundred and sixty-nine feet. About two miles south of the present outlet the divide must be only eighty feet above the lake. The highest point north of this valley before coming to the outlet is one hundred and twenty-one feet.

The prominent lowest points in the rim are therefore the following:—

	Feet.
Ashland ridge,	158
Centre Harbor ridge to Squam,	160
Squam Lake by Long Pond,	40
Ridge to Saco waters,	219
Ridge to Cocheco River,	72
Old outlet in Gilford,	80

Hence a rise of the Winnipiseogee Lake forty feet would cause a flow into Squam Lake; a rise of eighty feet would allow water to flow both into the Cocheco and what appears to be an old outlet through Gilford, towards Lake Village. A rise of one hundred and fifty-three feet would be required to make a direct connection with the Pemigewasset valley, the route *via* Squam Lake being very tortuous.

The existing outlet is an interesting stream. It expands immediately after leaving the lake into Long Pond, being navigable for steam tugs, through the passage way. The dam of the Lake Company at Lake Village prevents farther navigation, but in a mile or two it expands and sends off two bays, called Winnisquam Lake and Round Bay. There are two more expansions in Belmont, Tilton and Northfield, called Sanbornton and Little Bays. The water then descends rapidly to the Pemigewasset at Franklin, the two streams combined becoming the Merrimac. The total descent of the outlet for its fourteen miles' course is one hundred and seventy-three feet. It flows almost entirely over the hard pan or glacier drift deposits, and seems to have made no terraces above fifteen or twenty feet in altitude. No others exist above the west corner of Belmont, and those seem to have been formed in connection with the Pemigewasset.

The striking feature of this lake border is the absence of terraces. The banks are chiefly of glacial drift. The few terraces that may be seen are of limited rise. The following are the principal ones:—

At Alton Bay two,	55 and 75 feet.
West Alton two places,	75 and 100 feet.
Several places in Gilford,	10, 31, 47 and 80 feet.
Plain of Laconia, perhaps	10 to 12 feet.
Meredith Village,	5, 15, 23 and 30 feet.
Moultonboro,	75 feet.
Wolfsboro,	25 feet and more.
Centre Harbor Village,	8 to 10 feet.

Periods in the History. We can trace no less than ten periods in the history of this lake basin.

1. Period of the deposition of the *Porphyritic Gneiss or Granite.* This is the oldest formation in the state. A range of it starts southerly from Waterville and proceeds southeasterly to Mt. Prospect in Holderness. Thence it courses more southerly,

proceeding to New Hampton Centre Village. In this vicinity it is developed more perfectly than in any other part of the state. At this village it makes a sharp turn eastward to Meredith Village thence northeasterly nearly to Squam Lake in the extreme northeast part of Centre Harbor. It then makes another sharp turn down both sides of Meredith or Northwest Cove and appears also on the islands off Weirs, and the north part of Gilford. It now rapidly diminishes in width and is covered up, though appearing again in West Alton, and is last seen in the south part of Alton.

2. *Winnipiseogee Lake Gneiss Formation.* This is a granitic gneiss filled with segregated veins and has not yet been observed away from the vicinity of the lake. It does not appear upon any mountains, nor in bluffs; and has everywhere been greatly denuded so that its ledges are inconspicuous. It joins the first named rock everywhere on the east and covers it in Alton. The strata are highly inclined and sometimes inverted.

3. *White Mountain Series.* This rock is often characterized by the presence of andalusite. It crops out in Gilford and Alton and bounds the lake gneiss on the east where the junction is not obscured by overlying formations.

4. The next great period may represent the time of the *Elevation and perhaps Metamorphosis* of the three groups already enumerated. We possess no decided evidence to show that these three groups are unconformable with one another. The presumption is that these groups belong to the Laurentian system; they are certainly Eozoic.

5. *Eruption of the Granites of the Ossipee Mountains.* In a paper presented last year, a description was given of the rocks among the White Mountains; where it was stated that the upturned edges of the White Mountain series were covered first by a layer of coarse granite and then by a spotted granite. Both these varieties are found in the Ossipee Mountains, and in a similar stratigraphical position.

6. *Deposition of Felsites or Compact Feldspars.* Enormous thicknesses of variously colored felsites cover the spotted granite

of Ossipee and form the summits of the pile of mountains. None of the *Ossipyte*, a compound of labradorite and chrysolite, has yet been seen. These granites and felsites together constitute a great system of formations which I suppose are the equivalents of the Labrador system of Logan. He has not given the limits of his system, but I retain the name suggested by him, for the system of granites and compact feldspars developed so finely in New Hampshire. There is an extensive mass of granite in Wolfsboro and New Durham which may be connected with the Labrador system, but its relations have not yet been made out with certainty.

7. *Eruption of Sienite.* The Belknap Mountains, certain peaks in Alton, Diamond Island and probably Rattlesnake Island in Winnipiseogee Lake, and Red Hill in Moultonboro and Sandwich, are composed of sienite of various textures, which seems to have been erupted after the deposition of the felsites. Its age is shown by the fact that it cuts the ossipyte in Waterville.

8. *Deposition of Mica schist.* This formation is enormously developed in Strafford and Rockingham counties, touching the lake only at Alton Bay. It evidently covers all the formations thus far specified.

This is the last of the solid rocks in this area. There succeeds an enormous interval of time of which we have no record in New Hampshire. The country must have been elevated so that no deposits could be formed. The interval embraces the principal portion of the fossiliferous rocks.

9. *Glacier Period.* The phenomena of this age about the lake are striæ, embossed ledges, pot holes, beds of clay, bowlder drift, etc.

The courses of the striæ usually agree with the course of the valley, or from S. 25°–30° E. The following are compass courses of a number that I have measured.

Ashland Village,	S. 30° E.
Centre Harbor, commonly,	S. 30° E.
Holderness, top Prospect Mt.,	S. 25° E.
New Hampton Village,	S. 40° E.
New Hampton Centre,	S. 30° E.
New Hampton, N. E. part, above clay bed,	S. 25° E.
New Hampton, Harper's Hill,	S. 40° E.

Line between N. Hampton and Meredith,	S. 25° E.
Hill N. W. from Meredith Village,	S. 30° E.
" " " below summit,	S. 25° E.
East of Long Pond, N. Hampton,	S. 25° E.
Meredith Centre,	S. 15° E.
Highest hill, Meredith Neck,	S. 30° E.
Advent church, M. Neck,	S. 30° E.
Line between Meredith and Centre Harbor,	S. 28° E.
Gilford, hill N.E. from Lake Village,	S. 23° E.
Gilford, north part, on lake,	S. 25° E.
" N. E. part,	S. 30° E.
Alton Bay, ridge west,	S. 30° E.
Alton, east town line,	S. 30° E.
" farther west,	S. 25° E.
New Durham, commonly,	S. 30° E.

The striæ at the north and south ends of the hydrographic basin differ from those just enumerated.

Down the valley of Baker's River, from Warren through Wentworth to W. Rumney,	south nearly.
Rumney, varying slightly with valley,	S. 40° E.
Plymouth Village,	S. 50° E.
Holderness, Shepard's Hill,	S. 50° E.
Holderness, Squam Mountain,	S. 50° E.
Sandwich, west part,	East.
Near Tuftonboro Corner,	N. 80° E.

These observations indicate that ice moved down the valley of Baker's River in a southerly direction, but when the course of the valley changed the ice went with it, and passed southeast, and finally easterly over Plymouth, Squam Lake and to the north of Ossipee Mountains. After the ice had commenced moving easterly it continued in that direction, passing out of the Pemigewasset valley, and that even though it climbed the Squam Mountains. Facts are wanting to show whether the ice continued to move easterly after passing the Ossipee Mountains. Unless these easterly courses were made in the decline of the ice period, a portion of it must have been deflected by the Ossipee Mountains so as to excavate the S. 30° E. groovings along the lake valley.

We had supposed the ice continued in its southerly course after passing the lake basin, but a recent observation in Tuftonboro indicates that it turned again to the east passing up the water-shed between the lake and Ossipee River. It is possible this easterly course was induced by the blocking up of the direct path by the

low summits of Cropplecrown, Moose Mountain, etc., about Middleton. In that case part of the ice may have moved more easterly and part more westerly, so as to correspond with the common direction of the striæ in southern New Hampshire.

Pot Hole. On Beach Hill, New Hampton, there is a pot hole worn out of the rock, about four feet deep and two feet in diameter, at an elevation of four hundred feet above the lake. It is not in the line of any river course. People in the neighborhood ascribe it to the handiwork of Indians. It seems to belong to that class of pot holes in New England, which were made by torrents of water, falling through crevasses in the ice of the glacier. My father ascribed them to the action of ancient river courses, posterior to the drift period, and therefore inferred an immense erosion of rock, sufficient to have removed the rims of the ancient valleys.* It seems to me much better to assume a different theory for their excavation, and then we can avoid the difficult conclusion involved in the other supposition.

Clay Beds. The discovery of two beds of clay situated in the glacier drift in New Hampton and Laconia presents a phase of glacial action never before mentioned, so far as I am informed. It is not the bowlder clay, but a finely stratified deposit without stones and covered over by earth containing striated bowlders. The first is at Weirs, a steamboat pier connecting with the Boston, Concord and Montreal Railroad. It is about one hundred feet thick, with the base nearly at the level of the lake. It is stratified throughout, and no bowlders can be found in it, save what may have fallen from above. It is extensively excavated for the manufacture of bricks. Perhaps its area is oval in shape, forty rods in diameter. The bed in New Hampton is smaller, but more elevated, being five hundred and fifty-five feet above the lake or ten hundred and fifty-six above the ocean. It is four hundred feet above the ridge between Ashland and Meredith, and its drainage goes into the Pemigewasset. We pass four hundred and thirty-three feet below the base of the clay towards the river before reaching any stratified sand, the area between being occupied by the unmodified glacial drift. The clay in New Hampton falls quickly into small angular pieces, when dug into, as if it had been

* Geology of Vermont, vol. i, p. 216.

compressed laterally by ice. The strata slope five or six degrees toward the valley. The second area shows over one or two acres only, and the material is, as before, utilized for the manufacture of bricks.

Were the first the only instance, it could be easily explained by supposing the outlet of the lake had been dammed up to the height of a hundred feet, and in the still water resulting clay had been deposited. Essentially this explanation, however, must be resorted to for both cases. The existence of ponds of water must be assumed in order to explain the deposition of clay. No natural barriers now exist to form the pond on the New Hampton hill. The ice must have constituted the barrier, while still in slow motion southeasterly. Either a deficiency in the material or a partial thawing of the ice may have left a hole which became filled with water. In both cases the hill rises considerably back of the clay. This would allow streams of water to flow down into the ponds, carrying fine particles, which settle to the bottom, and thus produce clay. These clays are therefore accidental modified drift deposits, produced during the glacial period. Had the country been covered by icebergs during the glacial era, such beds ought to be common among our hills.

10. *The Terrace Period.* There are no evidences to show a submergence of the lake area by the ocean, unless it be derived from the existence of fresh-water smelts, apparently of the same species with their compeers of the salt water. No attempt has yet been made to find any marine animals in this large body of water by dredging. The terraces seem to indicate several former levels of the lake. Assuming this to be true, we can believe that Lake Winnipiseogee stood successively 100, 80, 55, 30, 20, 15 and 12 feet above its present level, but never any higher, or at least not long enough to allow sand to collect around the shores. Some of these terraces may be higher back among the Belknap Mountains, but it is only the height of this river terrace at its junction with the lake that indicates the former altitude of the water level.

With the elevation of the water one hundred feet the river at the Alton outlet must have been eighteen feet higher than now so as to prevent the egress of water. The present outlet may have been entirely closed. This we can easily appreciate, since

the drift ridge has evidently been excavated by running water more than this amount, as is indicated by the steepness of the present banks. There may also have been a barrier in Gilford to the south of the present outlet. Granting the existence of barriers in those directions, the outlet must have been through Squam Lake. Possibly there may have been a barrier across the Squam River also, where the valley is narrow, though all loose material is now removed from it. If so the outlet probably ran through Gilford.

There is nothing to indicate the nature of these barriers other than has been specified. Considering the character of the period, it is likely that there was earth in Alton and ice in the Gilford and Squam rivers. When the barriers had sunk twenty feet more, egress would have been checked only in Gilford. We may suppose at this epoch that the principal outlet lay to the south to the Cocheco River. As the lake sank more and more there might have been terraces formed locally at various levels, as our figures seem to indicate. But the level must have sunk to less than forty feet before Squam Lake could have existed separate from Winnipiseogee, and the outlet ran through its present channel. If the drift ridge at the Weirs gradually sunk by erosion, we can understand how the several local terraces mentioned above have been formed. Should there be another falling of the level a new set of terraces would appear, just beneath the present shore line.

The theory formerly prevalent respecting the origin of terraces supposes that the ocean was present to allow the gradual accumulation of sand and gravel beneath its retiring waves. The only objection to this view, proper to be mentioned at this stage of our paper, is that if terraces were made all the way up to one hundred feet there is no reason why others should not exist at twice and thrice that elevation. It is the absence of these higher terraces that led me to examine the surface geology of this region and to speculate whether this fact would not lead to the abandonment of the oceanic theory.

The true theory seems to be developed by studying the condition of the neighboring valley of the Pemigewasset and its connection with Winnipiseogee; for we have already seen that forty feet rise in the latter would carry its waters into the former valley, *via* Squam Lake and River.

The Pemigewasset and Merrimac rivers make an inclined plane

from the height of about five hundred feet (the same with the lake) at Plymouth to the ocean. The highest banks of sand of apparently fluviatile origin connected with the stream are the following. In most cases the measurements have been made with an aneroid barometer and may be regarded as approximations only to the truth.

HEIGHTS OF TERRACES	ABOVE		
	RIVER.	LAKE W.	OCEAN.
Plymouth	134	121	622
Ashland	? 154	121	622
New Hampton	? 260	311	812
N. Sanbornton	400	292	751
Franklin	140	30 below	470
Concord	125	50 below	450
Manchester	60 to 110 (falls)	250 below	250
Lawrence			20
Connected with these are a few others of interest.			
Holderness (tributary)	134	322	823
Principal terrace east of Plymouth	134	61	562
Height of rim between Squam and Winnipiseogee		40	541
Water-shed in Ashland	? 186	153	654
Terraces in Belmont	170	150	650

Perhaps the following generalizations may be drawn from these figures:

1. The highest level of sand or terrace descends rapidly from Plymouth to the ocean and more rapidly than the river itself.

2. The terraces near the ocean are not so much elevated above the river as those higher up the stream.

3. There is higher sand in New Hampton than in Plymouth and Holderness, farther north; nevertheless a tributary in Holderness holds about the same height, but this of itself does not necessarily prove the presence of the Pemigewasset water at this level. The sand is also greater in amount as well as height. It will be also noticed that the New Hampton sand is one hundred and fifty-eight feet higher than the Ashland water-shed leading to the lake, while the Ashland sand is thirty-two feet lower than this ridge. Why then should the sand have accumulated in New Hampton higher than this water-shed? We should naturally expect the stream to have gone over to the lake and carried the sand with it.

It seems clear that water must have gone to the lake through this Ashland-Meredith valley, for that is the direct course of the stream from north to south, and it may be that it carried sand also, since the terrace does not rise so high at Ashland as below. There is no detritus upon the lower side of the water-shed. The valley is entirely devoid of all loose materials.

Water at the height of eight hundred and twelve feet would also flow into Winnipiseogee through Squam, but would carry no material with it, as the course is tortuous and northeasterly.

Inspection of a map will show a great bend in the Pemigewasset just below Ashland. This may explain the unusual accumulation of sand in New Hampton; for when a river passes around a bend there is always a deposition of sediment held in suspension. With a powerful stream filling the valley, coming down from the north, there would be an immense amount of sand which would be checked by this point of land and deposited. The most noticeable mass of sand in New Hampton is arranged much like a terminal moraine just as might be expected upon this view.

4. The terraces upon Winnipiseogee River are quite different from any upon the Pemigewasset. Above Belmont they do not exceed fifteen feet in height. On the Mill Stream in the west corner of Belmont the terraces are six hundred and fifty feet above the ocean and one hundred and seventy above the river and they are continuous hence on either side to the Merrimac valley, while the river almost uniformly flows over hard pan.

These facts afford the inference that these high terraces in Belmont, Northfield and Sanbornton, are made by the Pemigewasset back water and not by the Winnipiseogee. It would result from this view that the outlet of the lake lay in some other direction at the time of the formation of these higher terraces and that a barrier kept back the river water from commingling with the lake. The terraces agree nearly in height with the Ashland-Meredith water-shed. If we suppose the waters of the Pemigewasset poured freely into the Winnipiseogee basin through the Squam, Ashland and the outlet avenues, at the height of one hundred and fifty or one hundred and seventy-five feet, we can understand why the main stream still went down the Merrimac, as the land descended more rapidly in that direction.

We conclude that the outlet made only small terraces, while the upper sands must be referred to the high water of the Pemigewasset. The connections through the several avenues would not be such as to carry detritus to the still water of the lake.

5. In general, therefore, without pointing out further details, we may refer the origin of the Merrimac terraces to the action of the river alone without the necessary presence of the ocean. This conclusion agrees with the generalizations of Prof. J. D. Dana,

respecting the origin of river terraces. The fluviatile origin of the Merrimac valley sands has been for many years a favorite topic of conversation with Hon. S. N. Bell of Manchester, N. H., elected to this Association in 1853. It was in consequence of suggestions from him that I was led to understand the proper source of the Merrimac sands, and to compare them with the scanty surface deposits about Winnipiseogee Lake. Mr. Bell also accompanied me in exploring the borders of the lake.

NOTE UPON THE CRETACEOUS STRATA OF LONG ISLAND. By C. H. HITCHCOCK, of Hanover, N. H.

UPON a geological map of the United States recently prepared by myself, with the coöperation of W. P. Blake for the western portion, and published in the third volume of the "Report of the Ninth Census," I have represented the north shore of Long Island as Cretaceous. "The American Journal of Science and Arts" in noticing this map (III. Vol. vi, p. 66) recommends certain improvements for future editions; one of which is, "to take away the green color, which means Cretaceous, from the whole of the north side of Long Island, no facts making the region Cretaceous."

With attention thus pointedly drawn to the subject I have recalled the reasons for representing this portion as Cretaceous. Notwithstanding the evidence is so probable in its favor, it is surprising to observe that mine is the first published map that colors this area correctly. It is represented either as Tertiary or alluvial upon the geological map of the "New York Geologists," 1842, upon my father's and Marcou's map of the United States, 1853, upon H. D. Rogers' map, 1858, and upon Sir W. E. Logan's map of Canada and the adjacent portions of the United States, 1868, the latter part having been prepared under the supervision of Prof. James Hall.

W. W. Mather, in his report upon the Geology of the First District of New York, pp. 272, 273, states that what he has called

"Long Island Division" must be Cretaceous. The following is his language: "It follows from these facts, that the lower part of the Long Island Division, embracing the white, mottled, red and pyritous clays, with their associated beds of gravel, conglomerate and sand containing lignite, are geologically equivalent to the beds in New Jersey called by Prof. H. D. Rogers the "Potter's clay formation," and to the lower division called by others the "greens and formation," "Ferruginous sand formation, Cretaceous formation," etc.; and that the overlying loams and clays containing the green earth with associated sands, gravel, etc., are equivalent to the green marl deposit, or to the tertiary, or perhaps to both those periods."

Prof. H. D. Rogers makes no reference to these rocks in his New Jersey Report. Nor does Prof. G. H. Cook, the present State Geologist, though he favored me with a letter affirming his belief in the Cretaceous age of this formation. An inspection of his map shows this division, called "Plastic clays," coursing from Wilmington, Del., to the vicinity of Philadelphia and Trenton, and thence direct to Staten Island. The strike prolonged a short distance impinges upon the west end of the Long Island Division. Hence from geographical distribution we should expect to find this Plastic clay prolonged into Long Island.

Furthermore, both the Plastic clay and the Long Island Division contain much lignite, and are fresh water accumulations, while the Tertiaries are of marine origin. This feature will separate the rocks under consideration from everything else.

I have information that E. Lewis, Jr., of Brooklyn, L. I., has recently discovered Cretaceous fossils in this group; which will soon be described in the Popular Science Monthly. Dr. Newberry has also discovered Cretaceous plants upon the island. I may add that I delivered a lecture, in the winter of 1869, before the Long Island Historical Society upon the "Geological History of Long Island," in which the Cretaceous age of this clay and sand deposit was affirmed to be as stated above. The essential facts of this lecture were stated also before the Lyceum of Natural History in New York, the same week.

NOTE.—While this paper is passing through the press, I observe that Prof. Dana has modified the statement quoted above in the October number of the Journal, to the effect that the Report of Prof. Mather affords a sufficient reason for the representation of the Cretaceous upon Long Island.

ARTIFICIAL SHELL HEAPS OF FRESH-WATER MOLLUSKS. By C. A. WHITE, of Brunswick, Me.

THE characters of the Kjoekkenmoedding or shell heaps of marine coasts, both of Europe and America, are too well known to need explanation in this connection, but the fact that similar accumulations are common upon the banks of the interior rivers of the United States is not so well known. It is true, however, that Atwater, Brinton and Wyman have at different times published notices of artificial accumulations of the shells of fresh-water mollusks. Although Professor Wyman's observations were made with his usual great accuracy and care, the accumulations he described were so near the sea-coast (in Massachusetts and Florida) that the report he gave of them did not seem to attract that distinctive attention which they merited. Consequently it was then hardly suspected that the former aborigines of North America made habitual use of fresh-water mollusks for food.

Observations made by the writer, during the five years just passed, along the Mississippi and its tributaries, in the states of Minnesota, Iowa, Illinois, Missouri and Indiana, establish a knowledge of the fact that shell heaps of the kind referred to are very common; and that the mollusks, whose shells are thus accumulated, belong almost wholly to the family Naiades and mainly to the numerous species of Unio prevalent in those waters.

In general character these fresh-water shell heaps resemble those of marine coasts but they are usually not so extensive. They vary in extent from a few bushels of shells to accumulations from fifty to a hundred yards long, four or five yards broad and from a few inches to a yard or two in thickness. They are usually located upon the immediate bank of the river, sometimes a little below and sometimes above the reach of the highest floods.

Although many of these heaps have been examined so far as to determine their real character, only a few of them have been examined with care.

The three most interesting of these were found near the villages of Keosauqua, Sabula and Bellevue, Iowa; the first upon the bank of Des Moines River and the other two upon that of the Mississippi.

At the first named locality the shell heap rests upon the ordinary alluvial soil of the river bank and consists of shells of

about a dozen species of Unio intermixed with silt derived from the water of the river at the time of its high floods, which at intervals of a greater or less number of years are known to cover the spot. All the species of mollusks found in the heap are now living in the river close by, just as they were living, without doubt, when the heap was formed. As they could be obtained only at the time of low water it was not necessary to carry them to higher ground.

Upon digging into the heap, pieces of limestone from the cliff near by were found laid together, with evident traces of fire upon them and with charcoal and fragments of rude pottery scattered about them. Sharp flint flakes, flint arrowheads and one greenstone axe were also found in the heap.

The pottery was rudely ornamented by irregular and interrupted parallel lines made while the clay was soft, by some pointed instrument and by having been also impressed at different places by twisted strings. It is composed of coarse common clay intermixed with some sand and slightly burnt.

The bones of the common deer (*Cervus Virginiana*) and snapping turtle (*Chelydra serpentina*) were also found intermixed with the shells. The long bones of the deer were all broken and split in the usual manner, doubtless for the purpose of obtaining the marrow.

At Sabula ten species of Unio were recognized in the heaps, together with bones of the common deer, wild goose (*Bernicla Canadensis*), snapping turtle, soft-shelled turtle (*Trionyx ferox*), cat-fish (*Pimelodus*), sheep's-head (*Amblodon grunniens*) and a few other undetermined fragments.

Fragments of the usual coarse pottery were also found in the heaps here, the clay of which was intermixed with comminuted shells. One piece of it was ornamented by a spiral groove of several coils, making a figure of oval outline. The same species of Unio, and in about the same proportionate numbers as are found in the heaps, may now be obtained living from the river close by. The deer is still occasionally found near there, and the ponds and bayous still afford the same species of aquatic birds, reptiles and fishes, the remains of which are found in the heaps.

At Bellevue eleven species of Unio and one of Alasmodonta were recognized in the heaps, all of which still live in the adjacent waters of the Mississippi. In these heaps were also found flint

arrowheads, pieces of pottery the clay of which had been mixed with comminuted shells, and also bones of the deer and buffalo (*Bos Americanus*).

The shell heaps both at Sabula and Bellevue are smaller than many others, but they afford some peculiarly interesting characteristics. These consist in traces of rude methods of cooking the unios and other articles of food, practised by those who accumulated the shell heaps.

In the argillaceous soil upon the banks of the river numerous small pits were dug, about half a yard wide and of like depth. These are now found closely filled with shells among which are fragments of the bones of such animals as were also used for food. The sides and bottom of the pits, as well as some of the shells and bones they contain, show traces of fire and pieces of charcoal were also found in some of them. The earth had evidently been heated by building a fire in the pits, the mollusks and other food then placed in them, then covered and the contents allowed to cook by the retained heat. The fragments of pottery found indicate that their vessels were of small size, and they were in consequence probably driven to this and other rude methods of cookery. Such a method of cooking must have been very imperfect, and we find that the two valves of many of the unios found in the pits still remain together, the mollusks having never been eaten, indicating that the cooking was insufficient or that the supply of such food was too abundant to require economy.

All the species of vertebrates, the remains of which are found in the fresh-water shell heaps, are occasionally or habitually used as food by civilized man, but not so with the fresh-water mollusks. The latter were, however, the chosen food of the people who accumulated the heaps. This is evident from the fact, that they are not obtainable at the time of greatest scarcity of food for savage men, namely, in winter and early spring, but on the contrary they are more easily obtained at times when other food is plentiful. That other excellent food was obtained and eaten with the mollusks is proven by the presence of its remains, as stated, in the shell heaps. Those who accumulated the heaps seem to have had little or no choice among the different species of Unio, since their relative abundance is about the same in the heaps and in the adjacent waters, where they are now living. In short they seem to have eaten all mollusks indiscriminately, the few gasteropod shells

(Melantho) found in the heaps being in about the same relative abundance with those now living. No pipes nor fragments of any have been found in any of the heaps.

The following table shows the species of mollusks and other animals, the remains of which were found in the heaps and pits at Keosauqua, Sabula and Bellevue.

SPECIES FOUND IN THE SHELL HEAPS OF KEOSAUQUA, SABULA AND BELLEVUE.

Species.		Keosauqua.	Sabula.	Bellevue.
Mammals.	Bos Americanus, ...			*
	Cervus Virginianus, ...	*	*	*
Birds.	Bernicla Canadensis, ...		*	
Reptiles.	Chelydra serpentina, ...	*	*	
	Trionyx ferox, ...		*	
Fishes.	Pimelodus sp., ...		*	
	Amblodon grunniens, ...		*	
Mollusks.	Melantho (Paludina) integra, *Say*,	*	*	*
	Unio aesopus, *Green*, ...	*		
	" anodontoides, *Lea*, . . .	*	*	*
	" crassus, *Say*;	*		*
	" ebenus, *Lea*, ...		*	*
	" gibbosus, *Barnes*, . . .		*	*
	" nodosus, *Barnes*, . . .	*	*	*
	" oratus, *Say*, ...	*	*	*
	" plicatus, *Say*, ...	*	*	*
	" pustulosus, *Lea*, ...	*	*	*
	" rectus, *Lamark*, ...	*		
	" rugosus, *Barnes*, ...	*	*	*
	" tuberculatus, *Barnes*, . .	*		
	" undatus, *Barnes*, ...	*	*	*
	" ventricosus, *Barnes*, . .		*	*

The important question now arises, By what people were these shell heaps accumulated and what is their age? Those of the interior are doubtless contemporaneous with those of the coast and all contained in, or connected with, both indicates that they were formed by people no farther advanced in civilization than those were who accumulated the Kjoekkenmoeddings in Europe, which are usually referred to the Stone age. We know also that this was the real condition of the greater part of the savage tribes of North America at the time of its discovery by Columbus. Especially was that the condition of the tribes that occupied the

region in which the shell heaps referred to in this memoir are found, as well as of those that then occupied the Atlantic coast. Therefore there can be little doubt that the greater part, if not the whole of the shell heaps of those regions, were formed by the people of the tribes referred to and their descendants, even down to the occupancy of the land by white people. It is true that the mounds of the probably more ancient "mound builders" are often found in considerable numbers in the immediate vicinity of the shell heaps of the interior, and it is probable that that people may have commenced some of these accumulations, but we have thus far no evidence of it. No copper, nor other metal, has been found in connection with the shell heaps, nor anything else that suggests their origin by people different from those who occupied the country at the time of the discovery by Columbus.

From the fact that the more savage people change so little as regards their habits of life, very little evidence of the lapse of time can be gathered from the remains of their rude arts. Therefore it is difficult to form a definite opinion in regard to the age of these American heaps. The entire absence of all articles of civilized manufacture, even those that savages most eagerly secure, seems to be very good evidence, however, that they are older than the date of the discovery. At Bellevue, Sabula and the Lower Rapids of the Mississippi also, oak and elm trees from two to two and a half feet in diameter were found growing in the soil that had accumulated upon the shell heaps. By counting the rings of annual growth of the trees, the age of the heaps upon which they grow is estimated to be not less than two hundred years. The condition of the shells in different heaps varied very much according as the soil covering them was clayey or sandy, the preservation being better in the former. No evidence has been obtained that any perceptible geological change has taken place since the accumulation of the fresh-water shell heaps began, except the usual washing away of the river banks such as sometimes takes place within a very few years.

The habitats, also, of the mollusks and other animals whose remains are found in the heaps, except such as has resulted from the occupation of the country by white men, remains unchanged. Therefore the conclusion as to their age is, that while some of the heaps may be, and probably are, very ancient, there has yet been no evidence obtained to prove them more than a few hundred years old.

On the Geological Relations of the Iron Ores of Nova Scotia. By J. W. Dawson, of Montreal, Canada.

The iron ores of Nova Scotia, long neglected, have recently begun to attract the attention of capitalists to an extent in some degree commensurate with their importance. The magnitude and variety of the deposits, the great richness of the ores, their proximity to the Atlantic and to great deposits of coal, are all features which give them very great economic value, and must eventually cause them to take no small part in contributing to the iron supply of the world. My purpose in the present paper is, with the aid of recent researches in which I have been occupied, to give a concise summary of the geological position and mode of occurrence of the principal deposits, and more especially of those facts which have been developed since the publication of my "Acadian Geology."

If we arrange these deposits in the first place under the two heads of *Beds* conformable to the stratification and *Veins*, we shall find that the former occupy three distinct geological horizons —that of the Lower Helderberg or Ludlow in the upper part of the Silurian, that of the Oriskany at the base of the Devonian, and that of the Lower and Middle Carboniferous. The latter occur in altered rocks, which may be assumed to be of Silurian age, in the Lower Carboniferous, and at the junction of these two groups of rocks. We may shortly consider the deposits of these several kinds and ages in their order.

I. Bedded Ores.

(1) *Great Hematite Bed of the Lower Helderberg Series.* This, in so far as at present known, is most extensively developed in the vicinity of the east branch of the East River of Pictou, and on the upper part of Sutherland's River. Here the rocks which rise unconformably from beneath the Carboniferous beds of the Pictou coal-field consist, in great part, of gray and olive slates, usually coarse and unevenly bedded, and with occasional calcareous bands, holding the characteristic fossils of the "Arisaig group," a series in Nova Scotia equivalent to the Lower Helderberg of American geologists, though in its specific forms more nearly allied to the English Ludlow than to groups of this age on the great inland plateau of America. These beds are affected with

slaty cleavages, highly inclined, much faulted, and folded in abrupt anticlinals, so that their detailed arrangement has not yet been satisfactorily traced. The great ore-band, which forms one of the most conspicuous marks for unravelling their complexities, has been traced mainly along two distinct lines of outcrop, both somewhat curved and broken, seeming to lie on the opposite sides of an anticlinal axis. It has also been recognized in two other localities where it must come up on distinct lines of outcrop, the precise relation of which to the others has not yet been ascertained.

The ore bed is accompanied by a thick band of olivaceous slates, and beneath this there appears hard ferruginous quartzite which Dr. Honeyman compares to the Medina sandstone. Lower than this and possibly unconformable to it are black and greenish slates with bands of quartzite and soft chloritic and nacreous schists which as yet have afforded no fossils. They are associated with hard beds or masses of rock rising into some of the highest eminences, and which have usually been described as trap, but which seem to consist for the most part of an indurated slaty breccia or conglomerate, corresponding very nearly in character to the typical graywacke of the older German geologists. These rocks may be of middle Silurian age, though possibly in part older, and we shall meet with them again in connection with the great vein of specular iron.

The ore bed, where most largely developed, attains a thickness of about thirty feet, and in places where it has been opened up by exploratory works, it has been found to afford from ten to twenty feet in thickness of good ore. This ore is a red hematite, sometimes compact and laminated, but more frequently of an oölitic character occasioned by the arrangement of the peroxide of iron in minute concretions enveloping grains of sand. By the increase of these siliceous grains it passes, in the poorer portions, into a sort of ferruginous sandstone. Similar beds of fossiliferous ore are well known to occur in the Clinton group of New York and Pennsylvania, and Prof. Hall informs me that they are found also in the Lower Helderberg series of New York.

Along the different lines of outcrop above referred to, this bed has been traced for several miles, and being of a hard and resisting character, it rises into some of the higher elevations of the country. Though not one of the richest ores of the district, its great quantity and accessibility render it highly important for

practical purposes. The analyses made of it show a percentage of metal varying from 43 to 54 per cent. The foreign matter is principally silica, and the proportions of phosphorus and sulphur are small—one of the specimens analyzed affording none whatever, another ·22 phosphoric acid and ·29 sulphur. These analyses were made at the instance of Mr. E. A. Prentice, now organizing a company to work this and other deposits in the district. The principal exposures of this bed are distant only twelve miles from the great collieries of the East River of Pictou, and less than ten miles from the Pictou and Halifax railway. This deposit was first described by Mr. R. Brown, in Haliburton's History of "Nova Scotia," 1829, and subsequently by the writer in "Acadian Geology." More recently exploratory works have been carried on and a practical report made by Mr. G. M. Dawson, Associate of the School of Mines, London; and the bed has been traced and collections of its fossils made by Mr. D. Frazer of Springville.

(2) *Hematite and Magnetic Iron of Nictaux and Moose River.* This deposit takes us to the other extremity of Nova Scotia, and brings us a stage higher in geological time, or to the period of the Oriskany Sandstone. It would indeed appear that the conditions of ore deposit, so marked in eastern Nova Scotia in the upper Silurian, were continued in the western part of the province into the Devonian. In many specimens of the Nictaux ore the chief apparent difference as compared with that of Pictou is in the contained species of fossils.

Where I have examined this bed, it appears to be six feet thick and enclosed in slaty rocks not dissimilar from those associated with the Silurian ore of Pictou. Recent explorations at Nictaux are said to have developed extensions of this deposit; but I have no details of them. As rocks of the Arisaig group are known to underlie the Nictaux beds, it is not impossible that additional beds of ore may be found in these. The normal condition of the iron of the Nictaux bed is that of peroxide; but locally it has lost a portion of its oxygen and has become magnetic. This I believe to be a consequence of local metamorphism connected with the immense granite dikes which traverse the Devonian rocks of this region.

The Nictaux ore is more highly fossiliferous than that of Pictou, and contains a larger proportion of phosphate of lime. In the

attempts hitherto made to work this ore, the distance from coal has been a main disadvantage, but the construction of the Windsor and Annapolis railway has diminished this. The Devonian beds holding this bed are described in "Acadian Geology." An analysis of a specimen made many years ago gave 55 per cent. of iron.

(3) *Bedded Ores of the Carboniferous System.* The most remarkable of these is a bed of crystalline *spathic iron* or siderite, occurring in the Lower Carboniferous series, near Sutherland's River in the County of Pictou. As described by Mr. G. M. Dawson, who prosecuted works of exploration in it last year, it is a conformable bed, occurring in the Lower Carboniferous red sandstones, and varying from six feet six inches to ten feet six inches in thickness. It is accompanied with smaller bands of the same mineral, and at no great vertical distance from it is a bed of gypsum. Its mode of occurrence is on the whole not dissimilar from that of the non-fossiliferous sub-crystalline limestones which occur in some parts of the Lower Carboniferous series associated with the gypsum. This ore is a true spathic iron, granular and crystalline in texture, and, when unweathered, of a light gray color. It affords from 42 to 43 per cent. of iron and contains from two to eight per cent. of manganese. This bed is only four miles distant from the "Vale" colliery, and is intended to be worked in association with the hematite already described, and with the other ores on the East River of Pictou possessed by the same proprietors. From the Report of Mr. Andrews on the second geological district of Ohio, it would appear that similar beds, though on a smaller scale, occur in the Lower Carboniferons series of that State. In Nova Scotia this bed is at present altogether unique.

Clay ironstones occur in many parts of the Nova Scotia coal-field. In the workings of the main seam of the Albion mines, Pictou, considerable quantities of nodular black ironstone are extracted, and will, no doubt, be utilized. In the beds under the main seam there are also clays rich in ironstone concretions. Beds with ironstone balls also occur in the measures north of the New Glascow conglomerate, and one of these is remarkable for the fact that the nodules were found by Dr. Harrington to contain nuclei of blende, a mineral otherwise unknown in the carboniferous of Nova Scotia. No attention has yet been given to these

ores as sources of iron, but it may be anticipated that a demand for them will arise in connection with the richer ores in the older formations.

II. Veins of Iron Ore.

(1) *Great Specular Iron Veins of the Silurian Slates and Quartzites.* In a paper on the metamorphic and metalliferous rocks of eastern Nova Scotia in 1848,* I mentioned the fact that the inland series of metamorphic rocks (bounding the coast series now known as the gold-bearing series) believed to be of Upper or Middle Silurian age, abound in veins of specular iron, associated with spathic iron and ferruginous dolomite, and occasionally with metallic sulphides, and I described some of these deposits. In the country eastward of Lochaber Lake, where this same formation occurs, not only are numerous small veins of specular iron and carbonate of iron found in it, but a rich vein of copper pyrites, noticed in "Acadian Geology," has recently been opened up and found to be very valuable.

In most parts of the region these iron veins, though very numerous, are of trifling thickness: but in two localities they are known to attain to gigantic dimensions, rendering them of great economic importance.

The earliest known of these was the great vein of the Acadia mine in the Cobequid mountains, discovered by the late Mr. G. Duncan, and on which I reported in 1845. These hills consist on their southern side of parallel bands of olive and black slate with beds of quartzite, all very highly inclined. The iron vein is a great irregular fissure, extending for many miles parallel to the bedding, and apparently accompanying a band of quartzite. It contains in addition to crystalline and often micaceous specular iron and magnetic iron, large quantities of a rich earthy red ore, which, from the crystalline planes which it presents, would seem to have been a carbonate of iron decomposed and oxidized. These iron ores are associated with large quantities of a crystalline ferruginous dolomite, allied in composition to ankerite. This may be regarded as the veinstone to which the iron ores are subordinate, and which in the thinner parts of the vein occupies nearly its whole breadth. At the outcrop of the vein it is in some

* Journal of Geological Society of London.

places weathered to a great depth into a soft and very pure yellow ochre. Small quantities of sulphides of iron and copper and of sulphate of barium are occasionally present. In addition to the above, which may be regarded as the primary contents of the vein, there occur in some parts of it secondary deposits of concretionary limonite, which have of late years afforded a very large part of the ore smelted by the Acadia Company.

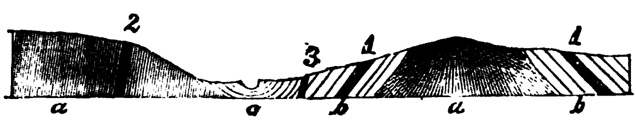
In some places the thickness of this vein has been found to be 150 feet, with intercalated masses of rock, but it is very irregular, diminishing occasionally to mere strings of ankerite. It is remarkable that in the Cobequid mountains, which are cut by transverse ravines to the depth of about 300 feet, the vein does not appear to be well developed in the bottom of the ravines, but only in the intervening heights. At first I was disposed to account for this by supposing that the deposit is wedge-shaped, diminishing downward; but I have more recently been inclined to believe that the large development of the vein is dependent on differences in the containing rocks which have rendered them harder and more resisting at the points of such greater developments.

With respect to the age of these beds, they must be older than the Lower Helderberg rocks which, both at the eastern end of the Cobequids and at the East River of Pictou, rest upon them. They are on the other hand probably newer than the auriferous primordial rocks of the Atlantic coast. As they have afforded no fossils their age does not at present seem capable of more precise definition. With regard to the filling of the vein fissures, this, if coeval with the metamorphism of the containing beds or immediately subsequent thereto, would fall between the period of the lower Devonian and that of the lower Carboniferous, or within the Devonian age. The denudation connected with the Lower Carboniferous conglomerates and the fragments contained in these conglomerates, seem to imply that the ore-bearing slates were then in the same condition as at present. On the other hand the Lower Carboniferous sandstones themselves contain in places narrow veins of specular iron, which also occurs, as well as magnetic iron, in the fissures of the Triassic trap.

On the west side of the East River of Pictou, there occur rocks precisely similar to those of the Cobequid range, of which indeed they may be regarded as an eastern continuation, and including

an iron vein which must be regarded as the equivalent of that of the Acadia mine, which it resembles perfectly in mineral character and mode of occurrence, differing only in the greater proportionate prevalence of the specular ore.*

In New Lairg, a few miles from Glengarry Station, the most western portion of this vein known to me contains much ankerite, with strings of specular iron; and in large loose pieces there are indications also of red ore which is not visible in place. Farther to the eastward on the west branch of the East River of Pictou, there appears a band of quartzite thirty feet thick filled with veins of Limonite; but specular ore is not found at this place. Still farther to the eastward and near the east branch of the East River the specular vein attains a very large development, showing in some places a thickness of twenty feet of pure ore. Its course is S. 60° to 70° E. or nearly coincident with that of the containing beds; and, as on the Cobequids, its attitude is nearly vertical and it appears to be thickest and richest in the rising grounds. In one very deep ravine the bed of quartzite usually associated with the ore seemed to be wanting, and the vein was represented by innumerable strings of ankerite, forming a network in the slate. As in the Cobequid vein, masses of magnetic ore are occasionally mixed with the specular. To complete the resemblance, loose masses of limonite are found in the vicinity of the vein, giving rise to the expectation that a vein or veins of this mineral may be found to be associated with the specular ore. The ores of this vein in Pictou county are nearly pure peroxide of iron, containing from sixty-four to sixty-nine per cent. of metal, and can be obtained in great quantity from the outcrop of the vein where it appears on the rising grounds.



Ideal Section, showing the general relations of the Iron Ores of the East River of Pictou.

1. Great bed of Red Hematite.
2. Vein of Specular Iron.
3. Vein of Limonite.

(*a*) Older Slate and Quartzite series, with Trap, etc.
(*b*) Lower Helderberg formation and other Upper Silurian rocks.
(*c*) Lower Carboniferous of the East Branch of East River.

* This vein was first described by the late Mr. Hartley in the Report of the Geological Survey of Canada, 1871.

(2) *Limonite veins of the East River of Pictou.* The valley of the East River of Pictou above Springville is occupied by a narrow tongue of Lower Carboniferous rocks, having at one side the slates containing the ore last mentioned, and on the other a more disturbed country already referred to as containing the great Lower Helderberg bed of hematite. It is highly probable that the river valley follows the line of an old pre-carboniferous line of fracture, denuded and partially filled with the Lower Carboniferous beds, including large deposits of limestone and gypsum. At the line of junction of the carboniferous and older rocks on the east side of the river, occurs the great limonite vein of the district, forming a vein of contact of exceeding richness and value. It follows the sinuosities of the margin of the older rocks, and varies in thickness and quality in different places, apparently richest opposite the softer slates where these are in contact with a black manganesian limestone, which here as in many other parts of Nova Scotia forms one of the lowest members of the Carboniferous series. The ore is sometimes massive but oftener in fibrous concretionary balls of large size, associated with quantities of smaller concretionary or "gravel" ore. In some places the ore of iron is associated with concretions or crystalline masses of pyrolusite and manganite.

Denuding agencies in the post-pliocene period have removed portions of the vein and its wells, and have deeply covered the surface in many places with débris. Hence the outcrop of the vein was originally marked by a line of masses of the ore too heavy to be removed by water. From the analogy of the other veins to be mentioned in the sequel I was led to believe that the source of these masses would be found in the Lower Carboniferous rocks, and so stated the matter in the first edition of "Acadian Geology" (1855). Subsequently, however, the vein having been exposed *in situ*, and one wall proving to consist of metamorphic slate, it was described by Dr. Honeyman and by Mr. Hartley of the Geological Survey as a vein in the Silurian rocks. Still more recently exploratory works conducted by Mr. G. M. Dawson, with the aid of Mr. D. Fraser, have clearly proved that the vein follows the junction of the two formations. The ore of this vein is of the finest quality, affording from sixty-two to sixty-five per cent. of metallic iron. The more productive portions of this vein, as well as of the specular vein in its vicinity, are in the hands of the parties already referred to, in connection with the hematite bed.

(3) *Limonite of Shubenacadie, Old Barns and Brookfield.* At the mouth of the Shubenacadie River, the lowest Carboniferous bed seen is a dark-colored laminated limestone, in all probability the equivalent of the manganesian limestone already referred to, as well as of the manganiferous limestone of Walton, the plumbiferous limestone of the Stewiacke, and the lower black limestone of Plaister Cove, Cape Breton.* This limestone, and the sandstones and marls overlying it, are traversed by large fissure veins, holding a confused aggregation of iron ores and other minerals, as limonite, hematite, gothite, sulphate of barium, calcite, etc., some of which appear sufficiently large and rich for profitable exploration. In the same formations, farther to the eastward, at Old Barns, similar veins are found to be largely developed, and at Brookfield, fifty miles east of the Shubenacadie, and apparently near the junction of the Lower Carboniferous with older rocks, large surface masses of limonite appear to indicate an extensive deposit of similar nature, but which has not, I believe, been yet so far opened up as to establish its practical importance.

(4) *Iron Veins of the Triassic Trap.* Veins of magnetite and specular iron occur in several localities in the great beds of trap associated with the Triassic red sandstones of the Bay of Fundy, but so far as known these ores are insignificant in quantity.

It will be observed from the above notes, that while the iron vein of the Cobequid hills is at no great distance from the coal-field of Cumberland, with which it has now railway connection, the still larger and more important deposits of Pictou are very near to the extensive collieries of that district, and to railway and water communication, so that every facility appears to exist for their profitable exploration, and it may be anticipated that they will soon be rendered available for the supply of iron of superior quality, more especially to meet the large and increasing demand of the Dominion of Canada.

* See Acadian Geology.

THE PROXIMATE FUTURE OF NIAGARA; IN REVIEW OF Prof. TYNDALL'S LECTURE THEREON. By GEORGE W. HOLLEY, of Niagara Falls, N. Y.

THE distinguished scientist whose writings have charmed so many readers, and whose instructive and brilliantly illustrated lectures, during the last winter, charmed so many listeners—Prof. John Tyndall—in the closing paragraph of a lecture on Niagara, delivered before the Royal Institute after his return to England, speaks of the future of Niagara in these words: "In conclusion we may say a word regarding the proximate future of Niagara. At the rate of excavation assigned to it by Sir Charles Lyell, namely, a foot a year, five thousand years will carry the Horseshoe Fall far higher than Goat Island. As the gorge recedes * * * it will totally drain the American branch of the river, the channel of which will in due time become cultivatable land. * * * To those who visit Niagara five millenniums hence I leave the verification of this prediction."

With these words for a text it is proposed to remark upon some points in the lecture which, as printed in the June number of the "Popular Science Monthly," contains thirty-nine paragraphs, taking them in reverse order, or from the end to the beginning.

Let us first inquire how Sir Charles Lyell arrived at the conclusion that the rate of excavation was a foot a year. In his "Travels in the United States," in 1841–2, vol. i, page 27, he says:—

"Mr. Bakewell *calculated* that, in the forty years preceding 1830, the Niagara had been going back at the rate of about a yard annually, but I conceive that one foot per year would be a much more probable *conjecture.*"

Thus we discover that the rate suggested was the result of a conjecture founded on a guess. From certain oral and written statements which the writer has been able to collect, he has, as elsewhere recorded,* made an estimate of the time required to excavate the present chasm-channel from Lewiston upward. In the last hundred and seventy-five years, certain masses of rock have been known to fall from the water-covered surface of the

* In a work quoted by Prof. Tyndall entitled "Niagara, its History and Geology, Incidents and Poetry."

cataract, and a statement as to the surface measure of each mass was made. In using these data it is supposed that each break extended to the bottom of the precipice, although the whole mass did not fall at once. Of course the substructure must have been worn out before the superstructure could have gone down. Father Hennepin, in his well known description of the locality as he saw it in 1678–80, says, "One may go down (on the Canada side) so far as the bottom of this terrible gulph. The Author of this discovery was down there the more narrowly to observe the fall of these prodigious cascades. From hence we could discover a spot of ground (?) which lay under the fall of water which is to the east (American Fall) big enough for four coaches to drive abreast without being wet." Seven years later the Baron La Honton, in reference it is supposed to the Canada side, says, "Between the surface of the water that shelves off prodigiously, and the foot of the precipice, three men may cross in abreast without further damage than a sprinkling of some few drops of water." We cannot assign less than twenty-four feet space to the "four coaches" moving abreast. The projection at the westerly end of the water-covered surface of Table Rock has diminished but little, since three men could now go under the sheet abreast if they had a proper footing, whereas the over-hang on the American side has almost entirely fallen, since there is now but a slight projection there of the surface rock. The huge pile of large bowlders now lying at the foot of the precipice indicates the same result. Authentic accounts of similar abrasions are the following, namely: in 1818 a mass one hundred and sixty feet long by sixty in width; in 1828 and 29 two smaller masses nearly equal in the aggregate to the last. Also in 1828 a huge mass, the top surface of which was called half an acre. In 1850 there fell a smaller mass about forty feet long and ten feet wide; in 1852 a triangular mass the base of which was forty feet and its altitude three hundred, extending south from Goat Island out beyond the Terrapin Tower, and in 1871, from the west side of the inner curve of the Horseshoe, another piece about ten feet by forty. Here we have some proximate data on which to base our calculations. In addition to these it is supposed that there have been abrasions by piecemeal that were not noticed and that equalled all the others.

Combining all these minor masses into one grand mass, and

omitting fractions, we find we have a magnificent bowlder containing twelve million cubic feet of rock. If this were spread over a surface one thousand feet wide and one hundred and sixty feet deep, the average width though less than the average height of the falls below the ferry, it would cover it to the depth of seventy-six feet. This for one hundred and seventy-five years is four inches per year. At this rate to cut back six miles would occupy seventy-two thousand years, or twelve thousand years for a single mile, a mere shadow of time when compared with the age of the coralline limestone over which the water flows. So, if our data are reasonably correct, more than twice as many millenniums as Prof. Tyndall has named will be consumed before his prediction can be fulfilled.

The next point in our text relates to the "entire drainage of the American branch of the Niagara River the channel of which in due time will become cultivatable land." A consideration of some facts connected with the physical features of the river, which his short visit doubtless prevented Prof. Tyndall from ascertaining, will compel us to put less faith in this prediction than in the one we have just considered. They are as follows: the surface of the water at Gill Creek, two miles up stream, is, by actual survey, fifty-two feet higher than the highest point of the falls below. The river just above the mouth of Gill Creek is twenty feet deep. Hence the *bottom line* of the river there is thirty-two feet higher than the *top* of the American Fall. It follows that if this fall shall ever reach Gill Creek and the bed-rock shall prove sufficiently strong to maintain its position, the fall will be about fifty feet higher than it is now.

Secondly, there stretches up from the head of Goat Island, about three-fourths of a mile, a rock bar, having about the same surface level as the bed-rock of the island itself. Undoubtedly it was once covered with soil and formed a portion of the island. This bar projects above the foot of Grass Island which lies about midway between it and the American shore. Toward the Canada shore, and near the centre of the river, is another bar composed of rock, bowlders and gravel about the same length as the last, and stretching much farther up stream. These two bars form, as it were, a partition separating the currents flowing down from the channels between Navy and Grand islands and between this last and the American shore. This is one of the finest reaches in the

upper Niagara. It is about three miles in width and flows on with a strong but unruffled current until it reaches the first break in the rapids above the falls. It is divided practically into three channels of nearly uniform depth, the difference in elevation between the two sides of the river having disappeared by the rising of the dip of the bed-rock. The first channel comes from the south, between the Canadian shore and Navy Island; the second and deepest from between this island and Grand Island, and the third from between Grand Island and the American shore. The water in the first channel, except in floods, passes down the Canada side. The other two channels are more or less blended and pass partly over the Canadian and partly over the American Fall. As has been before noticed, the rock bar stretching up from the head of Goat Island reaches above the foot of Grass Island. The channel inside of and next to Grass Island is deeper than that outside of it. The conformation of the bed of the river is such that the currents formed by these two channels unite and, diverging northerly, run diagonally toward the American shore, in which they have excavated quite a deep bay. From the foot of this bay is taken the water to supply the hydraulic canal which empties into the river half a mile below the falls.

Now we must bear in mind a fact which Prof. Tyndall and all others, who have written or speculated upon the geological character of the falls, seem to have passed without notice, namely: that whereas while they were *below* their present position they were constantly diminishing in height because they were receding with the dip of the bed-rock, *now* they are, so to speak, *rising* on the dip, the river making an acute angle with its former direction. By reason of this southwesterly declination of the bed-rock the surface of the water in the Horseshoe Fall, next to the Canada shore, is ten feet lower than that of the most northerly point of the American Fall. But with the change of direction in the channel of the river, this difference is fast disappearing and will be entirely neutralized when the falls shall have reached a point a few rods above the mouth of Chippewa Creek, a mile from Table Rock. To this change of direction and this upward trend of the bed-rock we are indebted for the existence of the rapids above the falls, one of the finest features of the locality. At no point below their present position could such a prelude—musical as well as *motional*—to the great cataract have existed, simply because

the water above the precipice lay like the water in a mill pond above its dam, over which it tamely falls to the level below. There were doubtless slight breaks in the current on the two sides of the river, produced by the suction of the shallow toward the deeper water in the centre of the stream. But they must have been tame and lifeless compared with the grand rush, tumult and roar of the present rapids. When these have vanished in the receding flood there can be no others that will equal them in length, breadth, beauty and power. The only reminder of them even, that can exist hereafter, will be seen by the traditional New Zealander who may stand on the dilapidated walls of Fort Porter and look upon the waters that will then rush down the slope of the corniferous limestone which forms the dam at the foot of Lake Erie.

Finally, in reference to this question of the "entire drainage" of the American channel, we have had a remarkable demonstration of the entire improbability of its ever occurring. This demonstration was made on the 29th of March, 1848. The preceding winter had been intensely cold; the ice formed on Lake Erie was unusually thick and covered nearly, if not quite, two-thirds of its surface. During the warm days of the early spring this great mass was, as is usual in such cases, loosened around the shores of the lake and detached from them. During the forenoon of the day named a stiff wind moved the whole mass up the lake. A little before sunset the wind chopped suddenly around and blew a gale from the west. This brought the vast field of ice back again with such tremendous force that it filled in the neck of the lake and its outlet so as to form a very effective dam, by which the outflow of the water was very greatly impeded. Of course it needed but little time for the falls to drain off the water below this dam. The consequence was that on the morning of the following day the river was nearly half gone. The American channel had dwindled to a deep and narrow creek. The British channel seemed to have been smitten with a quick consumption and to be fast passing away. Far up from the head of Goat Island and out into the Canadian rapids and from the foot of the island out beyond the Terrapin Tower the water was gone. The rocks were bare, black and forbidding. The roar of Niagara had subsided almost to a moan. The scene was desolate and, but for its novelty and the certainty that it would change before many hours,

would have been gloomy and saddening to those who witnessed it. Every person who has visited Niagara will remember a beautiful, broken jet of water which shoots up into the air from the Great Rapids about forty rods south of the outer Moss Island, called, with a singular contradiction of terms, the "Leaping Rock." This rock was laid entirely bare, and the writer drove out with a horse and carriage across the rocky bed of the river, near to and above it. This extraordinary syncope of the waters lasted all the day, and night closed over the strange scene. But during the night the dam gave way and the next morning the river was restored in all its strength and beauty and majesty, and the dwellers on its shores were glad to welcome its swelling tide once more.

By this occurrence the formation—the topography, so to speak—of the river bottom was revealed. A mile and a half above the head of Goat Island the waters were divided so as to form a huge Y through both branches of which they flowed over the precipice below, thus showing that nothing less than an entire stoppage of the water can leave the American channel dry, simply for the reason that in the main stem of the Y it is as deep on the American as on the Canada side.

But even if this portion of Prof. Tyndall's prediction should be verified, it is greatly to be feared that his "vision" of cultivatable land in the bottom of the American channel after the water has left it will prove to have been one with a most "baseless fabric." If the future possessor of that portion of the earth's surface should undertake, after it had been both over and under drained, to run his plough through it, he would not leave behind him, like a ship sailing in a starlit sea, a wake of phosphorescent illumination, but rather he would see before him an illumination resulting from the contact of rock and steel which might lighten his track in the darkest night. If Prof. Tyndall had found time to visit, on the Canada side, the cliff at the head of Foster's Glen or at the foot of the whirlpool, he would have had a "realizing sense" of what this kind of "farming" might be. One might more hopefully try to run his plough through the valley of Jehoshaphat in front of the Beautiful Gate, where he might possibly disturb the mural covering of some long forgotten Israelite; but in the dry bed of the Niagara he could disturb nothing but his own temper.

In the second paragraph preceding the one we have been discussing Prof. Tyndall makes this remarkable statement, namely: "The river above the fall bends and the Horseshoe immediately accommodates itself to the bending, following implicitly the direction of the deepest water in the upper stream;" thus making the *depth of water* the master element in determining the direction of the chasm, and inferentially the rapidity of abrasion; whereas the friability of the substructure, the greater or less induration and compactness of the bed-rock is the controlling factor in the solution of the problem. This is clearly demonstrated at the present time in the Horseshoe, Luna and American Falls. There are two notable angles of recession in the Horseshoe Fall. One of them lies in the midst of the deepest water with its upward direction bearing nearly southeast. The other angle and the one that has receded farthest from the edge of the precipice lies just north of the deepest water, and its upward tendency is nearly northeast.

The Cave of the Winds, under Luna Fall, is a deeper boring into the bed-rock than can be detected in any part of the Horseshoe. Fifty years ago the deepest channel on the south side of and near to Goat Island was eight rods farther south than it is now. The water has cut down and carried away more than forty feet perpendicular depth of bowlders, cobble stones, gravel and earth, and made for itself a deeper channel than it ran in before. The little Horseshoe, as it is sometimes called, is the deepest reëntering angle in the American Fall, while the deepest water on that fall pours over its angle or point of greatest projection, next to the American shore. Moreover by far the greatest abrasion known to have occurred within the historic period—that of the larger portion of Table Rock in 1850—was a lateral one over which no water was running, nor had been for more than a century except over a small portion of its southerly end.

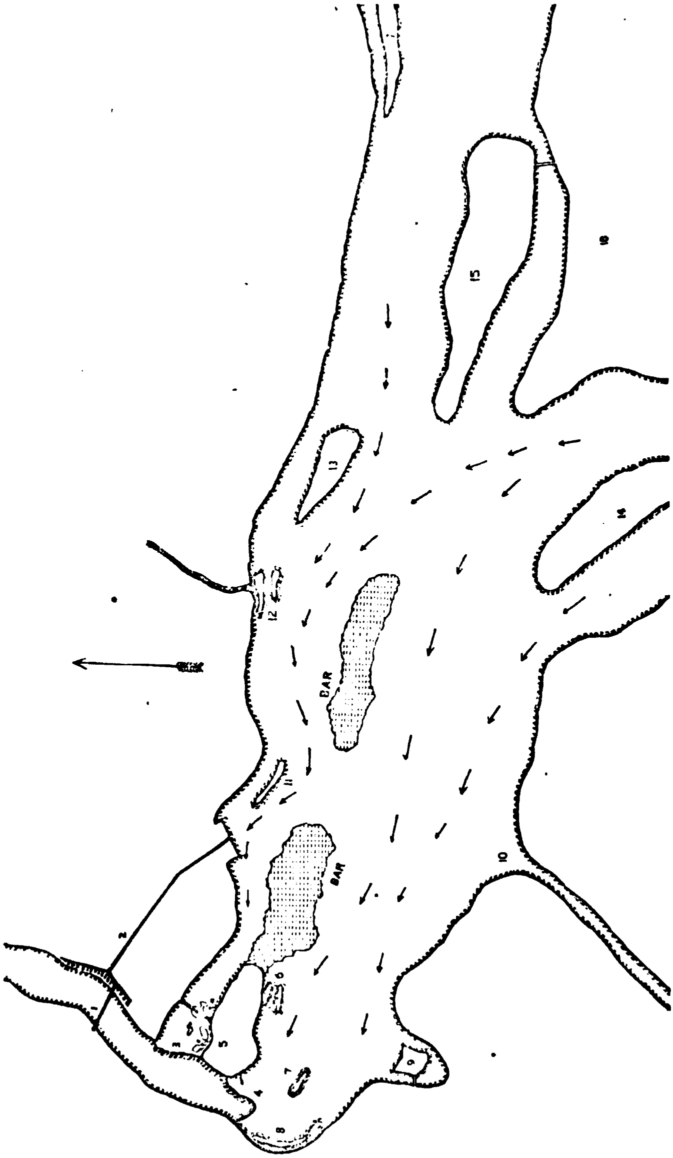
If the substructure upon which the water lies or over which it falls were homogeneous Prof. Tyndall's dictum would be correct. But there are scarcely ten consecutive square rods of the river-bed that can be called homogeneous.

With these facts before us we cannot resist the conclusion that it is the character of the river-bed, and not the depth of water, that solves the problem of recession, and that will determine both the proximate and distant future of Niagara, so far as its location is concerned.

"To complete my knowledge," says Prof. T., "it was necessary to see the fall from the river below it, and long negotiations were necessary to secure the means of doing so. The only boat fit for the undertaking had been laid up for the winter; but this difficulty * * * * was overcome." Two oarsmen were obtained. The elder assumed command and "hugged the cross freshets (?) instead of striking out into the smoother water. I asked him why he did so, and he replied that they were directed outward and not downward." If Prof. Tyndall had been at Niagara during the summer season he would have had the opportunity, daily, of seeing the fall "from below," and of going up or down the river on any day in a boat. All the boats (four) at the Ferry are "fit for the undertaking" and all of them are, very properly, "laid up in the winter," since they would be crushed by the ice if left in the water. Our oarsmen do not consider themselves very shrewd because they have discovered that it is easier to row *across* a current than it is to row against it. The party had an exciting and, according to Prof. T's account, a perilous trip. It *is* an exciting trip to a stranger, but the writer has made it so frequently that it has ceased to be a novelty.

"We reached," he says, "the Cave (of the Winds) and entered it, first by a wooden way carried over the bowlders, and then along a narrow ledge to the point eaten deepest into the *shale*." He also speaks of the "blinding hurricane of spray hurled against him." This last circumstance probably prevented him from noticing the fact that no shale at all is visible in the Cave of the Winds. Its wall, from the top downward some distance below where he stood, is formed entirely from the Niagara limestone. But it is checkered by many seams and so is easily abraded by the elements. The cave is the result.

Without noticing other statements that will illustrate the brilliant imagination of the distinguished "poet of science," and also the poetical license which is good-naturedly allowed to distinguished travellers, we may be permitted to remark, in conclusion, that Prof. Tyndall's style is so vigorous, animated and poetical, that one may be excused for preferring to read Tyndall's romancing rather than the most realistic utterances of many of his brother scientists.



No.	No.	No.
1. Suspension Bridge.	6. Moss Islands.	13. Connor's Island.
2. Hydraulic Canal.	10. Chippewa Creek.	14. Navy Island.
3. American Fall.	11. Grass Island.	15. Buckhorn Island.
4. Horseshoe Fall.	12. Gill Creek.	16. Grand Island.
5. Goat Island.		

On some Expansions, Movements and Fractures of Rocks, observed at Monson, Mass. By W. H. Niles, of Cambridge, Mass.

In the "Proceedings of the Boston Society of Natural History," vol. xiv, 1871, there was published an account of "Some Interesting Phenomena Observed in Quarrying." It was my object in that paper to give simply a preliminary account of the phenomena to be observed at Monson, Mass., rather than to inquire into the causes which produced them. Since that time the phenomena have increased in frequency and extent, and have thus given me some further acquaintance with the nature of the force producing them, and it is my object at this time to communicate to the Association some of these additional observations and conclusions. For a satisfactory statement of these, however, it may be important to refer briefly to certain observations which have already been recorded.

At the eighth meeting of this Association held at Washington, D. C., 1854, Prof. John Johnston of Middletown, Conn., read a "Notice of Some Spontaneous Movements occasionally observed in the Sandstone Strata in one of the Quarries at Portland, Ct.," which was published in the Proceedings of that meeting. The movements were in one of the quarries which had been worked to a considerable depth. Whenever the workmen attempted to open the bottom stratum of the quarry by making a long easterly and westerly channel in the rocks, they found that before they were able to cut quite through the bed, the portion of the stone remaining at the bottom of the channel was "crushed to fragments with a loud report, by an enormous lateral pressure." The walls of the channels sometimes approached each other three-fourths of an inch. These movements, however, were perceptible only in northerly and southerly directions. Prof. Johnston's conclusions were as follow: "These facts I think plainly show that the strata of sandstone at this place are not at the present time perfectly at ease in their ancient bed, but that in some way they have received a disposition to change slightly their position; and it becomes an interesting question to determine the cause, a question, however, upon which I do not propose now to enter."

So far as I am aware, this "Notice" of Prof. Johnston's is the only scientific record of such phenomena, observed at any locality

excepting Monson. It is true there have been verbal and newspaper reports of spontaneous explosions and fractures of rock at other places, but I do not know that they have received any scientific investigation.

The quarry at Monson, Mass., where most of the phenomena occur, is the one owned and worked by W. N. Flint & Co. It extends over an area of about five or six acres upon the gentle slope of a hill of moderate size.* The rock is gneiss, without any apparent planes of stratification, but with a distinct parallelism in the arrangement of the component minerals, that is, it has a schistose texture. Divisional planes, which are nearly parallel with the gently sloping surface of the hill, cut across the stratification and divide the rock into beds which vary in thickness from one inch and a half to five feet or more. These beds are very extensive and are not broken by any joints or other divisional planes. They lie, of course, nearly parallel with the surface of the hill and are, therefore, nearly horizontal in some parts of the quarry, while at some other places they have an inclination of about ten degrees.

EXPANSION OF THE ROCK:—One of the most interesting phenomena to be observed here is the expansion of the stone as it is broken either spontaneously or artificially from the rock.

The quarrying is mostly done by driving wedges into small holes drilled into the upper surfaces of the beds, in long lines parallel with the strike of the rock, thus splitting off stones of the required forms and sizes. Whenever a stone of considerable length is thus quarried from any entirely undisturbed portion of a bed it is found that the stone expands lengthwise, that is, with the strike, becoming slightly longer than the place on the edge of the bed from which it was broken. The most convincing examples of this movement are those where a long cleft has been made, liberating only one end of the stone, the other remaining attached to the bed by a perfectly solid connection. In such instances those parts of the drill holes seen on the side of the stone near its freed end are not directly opposite their respective parts remaining on the edge of the undisturbed bed, but they have moved from the attached end somewhat beyond them. As the bed and partly quarried

* For a more detailed account of the position of the quarry, the mode of working it and the peculiar phenomena, see "Proceedings of the Boston Society of Natural History," vol. xiv, p. 80.

stone are still solidly united at one end, it thus becomes clearly evident that either the stone must have expanded or that part of the bed must have contracted. That it is the expansion of the stone is proved by the fact that the freed end has moved from its original position upon the underlying bed. The amount of this expansion is best registered by the difference in position of the two parts of that drill-hole nearest the loosened end of the stone. In the autumn of 1869 a fissure of this kind, three hundred and fifty-four feet long, was made and then the amount of expansion was one inch and a half. That there is an actual expansion of the stone is further demonstrated by the fact that the parts of that hole which is nearest the solid junction of the stone and the bed apparently perfectly accord in position, while the want of agreement increases regularly with the distance from the end of the fissure.

These expansions are not mere occasional phenomena, but they occur whenever a perfect cleft of this kind is made in an entirely undisturbed portion of the rock. Since attention was first drawn to these expansions, now nearly four years ago, they have appeared so continually in every part of this extensive quarry, and in all beds, those near the surface as well as the deeper ones, that we may conclude that all the undisturbed rock there has this natural tendency to expand. These movements may be either up hill or down, but they are always in northerly and southerly directions, with the strike of the rock. I have made very careful examinations to see if there was a trace of any expansions in easterly and westerly directions, but have never seen the slightest indication of any. The bands of darker and lighter color caused by the schistose texture of the rock, which appear in any one bed, show no want of conformity with the parts of the same bands in the bed immediately below, even where there has been every opportunity for a tranverse expansion. The cause of this expansive tendency of the rocks must therefore be attributed to some force which acts or has acted in only these two directions. This fact alone would seem to show that the expansions are not produced by changes of temperature or of humidity, for I can see no reason why these should affect the stone in only northerly and southerly directions. That the expansions have occurred during all conditions of the weather, warm and cold, wet and dry, is another proof that the cause is not to be sought in meteoric changes.

Another interesting feature is that when the fracture is suddenly and thoroughly made, the expansion takes place immediately, and sometimes the expansive force itself completes the desired work. Before the wedges were driven I have drawn lines across what was to be the quarried stone to the part of the rock to be left undisturbed and then have carefully watched the operation. Under these circumstances I have seen the stone so suddenly spring into the elongated state that I am fully convinced that the rock there has by some means been laterally compressed in the beds, and that its elasticity or natural tendency to occupy its former space is always ready to expand it whenever an opportunity is presented. That certain beds of rock are by nature in a compressed state, and that they now possess an active expansive power, are I think demonstrated by the facts to be observed at Monson, and I believe that such a demonstration is new to science.

FORMATION OF ANTICLINALS:—Another instructive operation to be studied at Monson is the elevation of portions of the beds and the formation of anticlinals. Beds varying in thickness from the thinnest to four feet or more are thus disturbed, but most frequently the thinner sheets. The amount of elevation varies from one-quarter of an inch to three or four inches. The span of the arch thus formed is sometimes fifty feet, while some are only three feet broad. Usually the thicker the bed the broader the arch. The crests of the anticlinal always trend in easterly and westerly directions, and as the elevating and plicating force must work at right angles to the axis of the elevation produced, the power which forms these anticlinals must, therefore, be one which acts in northerly and southerly directions.

In the article on "Peculiar Phenomena observed in Quarrying" I considered the elevations as formed entirely by a lateral pressure, but subsequent observations have convinced me that the immediate cause of most of them, and probably of all, is the expansion of the compressed rock. This is particularly apparent where thin sheets have been loosened from the upper surfaces of thick beds and formed into anticlinals. Usually at each base of the anticlinal arch the edge of the folded sheet remains so closely attached to the underlying bed, that no lateral slipping of this edge upon the rock could possibly have taken place, nor could the bases of such an arch have approached each other, for the underlying rock

with which they are united remains undisturbed. It is evident that a line drawn from a fixed point at one base to the crest, then downward to a fixed point at the other base, would be a longer line than a straight one connecting the two fixed points, and therefore, that portion of the rock which is elevated and plicated must have expanded. There are abundant evidences at the quarry, some of which will soon be presented, that this tendency of the compressed rock to expand is a power fully competent to form such elevations. While, therefore, a lateral pressure may have compressed the rock yet, here evidently, expansion is the immediate cause producing the anticlinals.

We have become accustomed to consider the larger anticlinal and synclinal curves, and the contortions of strata in disturbed districts as produced entirely by an immense lateral pressure. But at Monson, to a certain extent we have the work actually in progress and we may calmly witness the plication of the beds. Besides the lateral pressure we find that the compression and the subsequent expansion of the rock are there important parts of the formative process. If now in our geological reasoning we interpret the past by the operations of the present, shall we not consider that the compression and the expansion of rocks have exercised an important function in the more extensive elevations and plications and in the formation of mountain chains?

Fractures of the Rock:—Another result of this rock expansion is the formation of numerous cracks and fissures attended sometimes by violent explosions. These recently formed, or now forming cracks, are the most common and most constant evidences of this power. When a portion of the bed has been quarried in such a manner that the expansive power of the rock is concentrated upon the narrowed part of the bed, the rock is not usually strong enough to endure the enormous force, and in such cases it becomes fractured and sometimes considerably shattered. So great is the power that beds of three, four and five feet and even of greater thickness are rent, sometimes for a hundred feet or more. In the latter part of June, 1872, says Mr. A. T. Wing, there was a natural breakage which extended about two hundred and seventy-five feet, and was about seventy feet back from the working face and parallel with it. One end of the loosened mass remained solidly attached to the undisturbed rock, and

by its expansion about ten thousand tons of rock were moved. Many other striking examples of the same movements might be given if it were necessary, and in most cases the expansion of the self-liberated stone is quite apparent, and the character of the fractures clearly shows that the power which produced them operated in northerly and southerly directions only.

These cracks and rents are more commonly formed slowly, but sometimes suddenly, attended not only by the breaking, shattering and even crushing of the solid rock, but by a loud report, and sometimes by the throwing of stones of considerable size for a short distance. On the morning of the eighteenth of June, of the present season, 1873, at about six o'clock, the engineer was startled by an explosion, and looking towards the quarry saw stones and other débris in the air being thrown to a considerable distance. I visited the spot on the twentieth and found it looking much as though a small but powerful earthquake had taken place. A bed five feet four inches thick had been ruptured in two nearly parallel fissures, each of which measured sixty-eight feet in length. Besides these the rock was otherwise much broken, and in places shattered and crushed, and some of the liberated stones were thrown southward, but there were none thrown in any other direction. These fractures were from eighteen to twenty-three feet from the working face of the bed.* There were very evident expansions of the rock from the north, southward. Sounds of the cracking of rocks are now rather common at the quarry, noises which are somewhat similar to the cracking of the ice on a pond. The facts connected with these explosions make it evident that they are produced by the sudden yielding of the beds to the enormous expansive power of the rock. These movements are in many respects similar to some earthquakes. May not the same disturbing power produce some of the slight earthquake shocks in non-volcanic districts?

Concerning the nature of the power which has compressed the rock, it is evident that it cannot be, nor can it have been any vertical force tending to elevate the rock, for any such upheaval would produce a tension of the beds rather than a compression.

*"Since this paper was read, but before going to press, another explosion has taken place by which a stone twenty-three feet long, of an average width of two feet, and more than two feet thick, was broken out of the bed, and had one end of it thrown more than two feet from the place in the bed from which it came. As this took place on quite a cold and cloudy day, it is evident that it could not have been caused by heat.

Nor can it be, as with the creeps in coal mines, the weight of overlying beds in the immediate vicinity, for the quarry has not been worked to a great depth, and these movements often take place in those beds immediately at the surface.

But is this merely a local power, or is it a local manifestation of an extensive force? Until observations have been made at many other localities it will be impossible to answer this question, but a few thoughts upon the subject may not here be out of place. The geological structure of the hill is such as to make it possible as a mere local phenomenon. The general form of the hill approximates that of a much elongated and considerably flattened half dome. The trend of the hill, like that of the other ridges in the vicinity, is nearly north and south, that is, nearly parallel with the strike of the rock. The eastern side is very steep; near the crest it is quite precipitous, and the edges of the beds appear from that side to form an immense arch. The western slope, near the southerly end of which is the quarry, is quite gentle excepting at or near the crest. If now we were at liberty to suppose that this arch of bedded rock has a tendency to sink or become flattened by its own weight or otherwise, then we could understand how the rock might be locally compressed in the directions of the trend of the hill. But I know of no evidence, nor yet of any facts other than the compression of the rock, that would even indicate that such a local subsidence is in progress.

But it is a significant fact that the phenomena in the Connecticut valley sandstone at Portland, Ct., reported by Prof. Johnston, show that the disturbing force there worked in the same general directions. Whether the rock there was in the same compressed condition or not, the facts there observed did not definitely prove, but the phenomena were of the same kind as those occurring here, which as we know proceed from compression. But whether the forces manifested at these two localities, and in entirely different rock formations, are distinct but of the same kind, or whether they are parts of one more extensive natural power manifesting itself only at these localities on account of the favorable conditions of the rock, we cannot now state.

That similar movements have not been observed at intervening localities would be no argument against their being parts of one largely distributed force. Not only might such movements have occurred without having been observed, but the great extent of the

beds, not strata, at Monson, without any joints or fractures is a condition very favorable for the manifestation of any such force.

But there are persons at other favorable localities now watching for similar manifestations, and if such appear they will be reported to me, when I hope to give the same study to the localities that I have to this one. I hope in this way, at length, to get at other facts which may give light upon the question, if not a solution to the problem.

THE GEOLOGY OF PORTLAND. By C. H. HITCHCOCK, of Hanover, N. H.

IN obedience to the custom of presenting a sketch of the local geology at the meetings of the Association, I have made some special examination of the rocks about Portland.

The earliest sketch of the geology of this neighborhood was published by my father, the late President Edward Hitchcock, in the Journal of the Boston Society of Natural History, vol. i, 1836, from observations made the previous year. He described the rocks by their lithological names, and represented them upon a map, with a section. These formations were grouped under two general heads; first, *Gneiss;* second, *Talcose slate.* The former was regarded as the older, corresponding in position and age with similar rocks in central Massachusetts. He called the clays tertiary, and was the first to describe the shell afterwards famous, *Nucula Portlandica*, for a long time believed to be extinct. Dr. C. T. Jackson also made a few allusions to the geology of Portland in his Geological Survey. I am not aware of any other publications before my report as state geologist of Maine in 1861–2. In that report it is stated that evidence exists for regarding the Portland clays and sands as covered by ice-drift, at least in part; but I did not commit myself to this view, not having examined the deposits critically and systematically. This view was upheld by my predecessors, in the use of the word tertiary, and by the unanimous belief of all the gentlemen with whom I came in contact in Maine.

This view was contrary to what I had seen of deposits of the same character in the Champlain and St. Lawrence valleys, and therefore I was not prepared to receive it without examination. This I have not been able to make till the present month, and the sequel will show that my first impressions were correct.*

One of the most thorough memoirs relating to the geology of the surface deposits of this neighborhood appeared in the first volume of the memoirs of the Boston Society of Natural History in 1865, by Dr. A. S. Packard, Jr., of Salem, entitled "Observations on the Glacial Phenomena of Labrador and Maine." He describes minutely all the localities in Maine where the fossils had been found in the clay, and presented interesting generalizations respecting the history of the entire Post-Tertiary period. This paper will for a long time continue to be the great authority upon these subjects for this part of the world.

I find also that Dr. T. Sterry Hunt has in some recent publications referred to the talcose and micaceous rocks about Portland.† I understand from conversation with him, that he believes they are to be referred to the Huronian, and that they are older than the White Mountain gneisses adjacent in Deering, Gorham, etc., because the gneisses along the Grand Trunk Railway in Maine have low dips, while the green schists are commonly highly inclined.

The general relations of the rocks in this vicinity will be understood by an inspection of our large geological map of Maine. Only three distinctions appear upon it, viz: Gneiss, Huronian and Cambrian. The first occupies a position along the shore from Gorham to past the Penobscot River. The second is limited to the towns east of the Saco River, including the islands in Casco Bay, and not passing east of Harpswell. The third lies to the west and northwest of Portland. My general theory of the structure is the following: The green schists were deposited in a basin of gneiss, now embraced between Harpswell and Saco River, in one direction, and between Deering and Westbrook and some ancient rim fifteen or twenty miles out to sea. Originally these talcose rocks may have extended fifty or sixty miles out to sea, and the force of elevation has crowded the outer rim of gneiss towards the interior, pushing up the schists into a highly inclined position. We have in the gneiss of Phippsburg and the Isles of

* Preliminary Report upon Geology and Natural History of Maine. p. 275, 1862.

† Presidential address at Indianapolis, p. 10.

Shoals, relics of the outer rim which borders the Huronian rocks on their ocean side. Before the submergence of the Gulf of Maine this ridge must have been prominent. The gneiss occupies a position along the shore from Gorham to beyond the Penobscot River, while the Huronian series is limited to Portland, and the towns east of the Saco River.

This view of the stratigraphical relations of the rocks in this region is derived from personal explorations this season, in connection with five years' work on similar formations in New Hampshire.

There is an interesting mass of granite to the west of Saco River in Biddeford, which is extensively used for building. It closely resembles the "Common or Franconia granite" of the White Mountains, which in my papers upon New Hampshire Geology is referred to the base of the Labrador System. It seems to have been poured out like lava among the mountains, and to have filled up a hydrographic basin four or five hundred square miles in extent. Dr. T. S. Hunt regards this Biddeford granite as exotic.* It seems to be surrounded by hard flinty slates.

The Huronian System. The following are the groups of rock referred to this system about Portland. Circumstances prevent their delineation upon a map.

Green unctuous schists, formerly called talcose, but now talcoid or hydro-mica schists (the ledges commonly exposed by excavations in the city limits are of this character; they commonly dip N. 30° W., at a very high angle, standing nearly vertical); variously dark colored quartzites; arenaceous mica schists; plumbaginous slates; pyritiferous slates; calcareous layers; argillo-mica schists; hornblende schists; soapstone; masses of chlorite, but rarely chlorite schists.

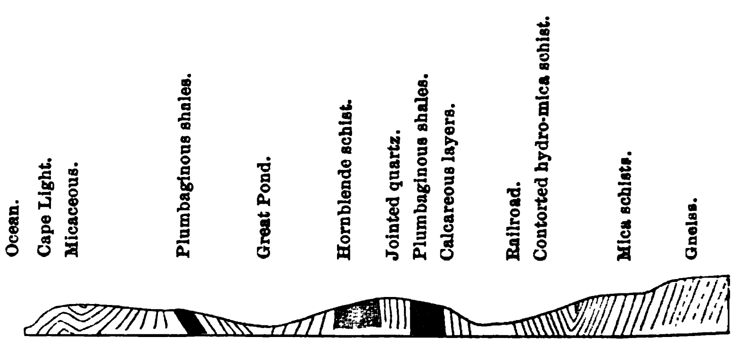
A drive along the sea-shore in Cape Elizabeth will bring all these varieties to view. At Knightsville, on the right, are calcareous layers; on the left, soft schists. Passing the ridge beyond a church, we can see ledges of quartzite. These are curiously cut by joints, often but two or three inches apart. They are similar to the jointed seams which have cut across the pebbles in the conglomerate at Newport, R. I. Next succeed hornblendic layers. Still farther along the outer coast line of Cape Elizabeth, one will see

* Amer. Jour. Sci., III, vol. i, p. 85, 185.

various varieties of mica, plumbaginous, and pyritiferous schists. At Great Pond the plumbaginous variety has in early times been dug into with the expectation of finding coal. I understand some imagine that coal can now be mined in this neighborhood. It should be stated plainly for the benefit of such persons, that exploration for coal in quantity in this vicinity will be entirely futile. And if search were to be made for this valuable mineral, no rock-cutting would be necessary since the strata everywhere stand nearly upon their edges, and their contents can be perceived by examining the surface.

An interesting variety of schist is that which splits up into pieces like rails. Some of them are ten feet long and are utilized by the farmers for fences, just like rails split from wood.

The blackboard will show a roughly drawn section across the Huronian, from Deering to the Cape Light House. There are in this at least six folds of the strata. Supposing that Half Way Rock is gneiss, we have in that and the similar rocks at the Isles of Shoals relics of the outer rim of the rock which borders the Huronian series on their ocean side. Before the submergence of the "Gulf of Maine" this ridge must have been prominent, as it certainly was while these green schists were being deposited.



SECTION FROM CAPE LIGHT TO DEERING.

I must here take issue with Dr. Hunt in respect to the relative position of the gneiss and green schists. Both of us agree in referring the former to the White Mountain series of New Hampshire, and the latter to the Huronian system of Logan, but he believes the latter is the older because the gneisses along the Grand Trunk Railway, in Maine, possess low dips, while the green schists are commonly highly inclined. The following reasons favor our view. 1.

At the line of junction, as observed in Deering, the two groups of rock possess exactly the same inclination, of 60° southeasterly. My father also remarked that on approaching the northern border of the green schists the dip decreased in pitch, corresponding with that of the gneiss. If in their naturål position, therefore, the gneiss underlies the schist. 2. The discovery of the outer rim from Phippsburg to the Isles of Shoals indicates a repetition of the underlying rock. 3. On comparing the similar rocks in New Hampshire, I find the upper and lower sides of the White Mountain series usually in contact with some other formation than the Huronian. Hence I should conclude, if the dip of the gneiss can be invariably established as lower, that it was formed, metamorphosed and elevated before the deposition of the Huronian system, and at the later period of elevation, the slates being more easily moulded, were forced into a more vertical position.

Perhaps some one may object to referring this series of schists to the Huronian, on the ground that lithological resemblances are not of sufficient consequence to justify identification. Fossils may be said to be necessary for satisfactory correlation.

The following are grounds for justification: 1. Logan, in 1855, described a system of rocks overlying unconformably the Laurentian gneisses about Lake Huron, which were distinguished by means of lithological characters. All geologists, therefore, who use the name Huronian, of necessity practically adopt this principle, though perhaps insensibly. We do not claim that a talcose rock can never be found in any other system than the Huronian, nor that gneiss may never be interstratified with the hydro-micas. Professor Dana's recent paper shows that gneisses, quartzites and limestones are interstratified in the Lower Silurian of western New England. 2. The rocks of similar lithological characters are separated from others in this instance by stratigraphy, and in no instance would we claim that mineral character is sufficient to distinguish systems without a study of the relations of the strata. We may sometimes generalize, and believe that rocks of similar mineral character must be of the same age, but such speculations always provide for confirmation by a study of the strata. 3. It has got to be proved that one kind of rock can exist upon one side of an axis and another upon the opposite side, or, in other words, that a gneiss can dip down a valley and come up on the other side as a chlorite schist. The presumption from all study is against such a supposition. On the contrary, continuity of min-

eral character indicates similarity of age till otherwise proved. The burden of proof is with our opponent.

Cambrian. These rocks crop out in Saco, a dozen miles west. They are clay slates and indurated argillaceous schists, the latter having a northwest strike, while the rocks of the older series run northeasterly. These rocks are in character and position allied to the Cambrian Paradoxides slates of Massachusetts, and exist in immense mass along the coast of Maine west of Saco, and in New Hampshire.

The slates in Saco are quarried for roofing purposes as well as slabs for sinks, billiard tables, etc. The Cascade Slate Co. have opened a ledge where a cliff of fifty feet altitude gives facilities for cleaving the strata. There is no difficulty in getting slabs ten feet long. Between the clay beds are harder strata with quartz veins carrying the mineral ankerite. I have found precisely similar veins in New Hampshire carrying gold, and presume the same mineral may be found in Saco, as well as in Portland. A geologist would have no reason to look for coal in this vicinity, but he would be justified in searching for the precious metal. This same view has been entertained by my father, Dr. Jackson, and Dr. Hunt. It should be said of the slates that they correspond in character with those at Brownsville, Monson, etc., in the Piscataquis region. As you are aware these slates command in the market a higher price than those from Vermont and Pennsylvania. They may be worthy of attention on account of the proximity of the ledges in this neighborhood to the sea.

In Windham there are two ranges of mica schist accompanied by scanty layers of siliceous limestone. The schist carries kyanite and staurolite, and hence probably belongs to the Coos Group of New Hampshire. I have been informed by Mr. Gould, Secretary of the Society of Natural History, that this mica schist has a course of N. W. and S. E. If so, this is a test locality to determine the correctness of a position I have assumed, respecting the radical difference in age between the Coos and White Mountain groups. If we have here mica schists with a N. W. strike overlying the andalusite gneiss, there is the same unconformability which I have described as occurring in the White Mountains. I refer the lower division to a place beneath the Labrador series, and the upper slates to some undescribed position above the Labrador.

POST TERTIARY DEPOSITS.

I have already indicated the opinion of my predecessors upon the matter of the succession of the Post Tertiary deposits. Recent examination has led me to assign a different order to them from that referred to, and I think all will admit that the evidence is satisfactory.

The succession, as I read the strata, is as follows:

1. The covering of this city and the whole surrounding country with an immense sheet of ice, which pushed towards the ocean, transporting bowlders and fragments of rock, rounding, scratching and polishing the ledges, or the *Glacier Period.*

2. A period of submergence to the depth of forty or fifty feet, in which arctic mollusks inhabiting the deep water, say three hundred feet, located themselves upon the very spot where we now stand. This is the period of the *Leda Clay.*

3. Sands containing shells of animals living on the sea-shore, the highest of them about one hundred feet above tide water. This is the *Saxicava Period.*

I proposed in 1861 the name of Champlain Period for the combination of the two just mentioned,—a term which has generally been adopted by American geologists. I first saw the distinction of lower and upper in the writings of Prof. C. B. Adams, in Second Annual Report upon the Geology of Vermont in 1846.

The names Leda clay and Saxicava sands were proposed for the subdivisions by Dr. Dawson of McGill College, Montreal, who has distanced all other collectors of these Champlain fossils by the enormous number of species which he has discovered. He has more than doubled the lists as given by all previous observers.

4. Over all these deposits, in the highest parts of the city, is a layer of yellow ferruginous gravel with rolled bowlders, usually two or three feet thick, but much greater on Bramhall Hill. As the highest part of Portland is about one hundred and sixty feet high, we are confident there has been a submergence great enough, since the Champlain Period, to cover entirely the city of Portland. To this we have heretofore given the name of *Terrace Period.*

I will not detain you with the details which might be presented on this topic. I will rather give my theory of the position of these several layers, and leave to the members of the Association the pastime of visiting such of the localities as they may desire. I have colored one of the beautiful maps of the city made by the

Coast Survey, upon which you may see at a glance the localities of interest. In its preparation the members of the Society of Natural History have aided me. The catalogue of fossils from this vicinity was prepared by C. B. Fuller, and the specimens upon which the determinations are based can be seen in the Natural History collections in the room above.

I will not raise the question whether Portland was more elevated than now in the glacial period. The general course of the striæ in this neighborhood is S. 15° to 20° E. There is a notable exception near Blue Point, Scarboro, where they run S. 20° W. The latter may have been made by floating ice along the sea-shore in a time of submergence. I have measured a few of the courses, which I mention:

Saco, slate quarry, S. 3° to 5° E.

Blue Point, S. 20° W. crossed by faint lines S. 10° E.

West edge Cape Elizabeth, Saco road, S. 15° E.

Evergreen Landing, Peak's Island, S. 10° E.

East side of Peak's Island, S. 20° E.

East side of Knightsville, running up hill transversely S. 5° E.

Cape Light, south exactly.

LOCALITIES OF FOSSILS.

Along east side of Munjoy's Hill, for four hundred yards between Eastern Promenade and Grand Trunk Railway.

Portland Company's Works, St. Lawrence street.

Adams street.

Between Fore street and Custom House.

Cove on Washington street opposite north end of Race Course.

From this point to Fox street.

Between Washington and North streets.

In an old pit on Congress street above Mountfort street.

Almost anywhere north of Congress street between Alder and Anderson streets.

Congress street north of Reservoir.

Old slide next Canal, described by Mr. Morse.

For two hundred yards at the foot of Emery street.

Knightsville, nodules containing shells, fish, etc., very abundantly in Deering, Westbrook, Cape Elizabeth and Islands in Casco Bay.

I will now give my reasons for saying that all these localities of fossils lie above the glacier drift.

Munjoy's and Bramhall hills are the true glacier drift. The large striated bowlders and accumulations of unmodified material abundantly present all the usual phenomena of this deposit. In every case the strata containing the fossils dip away from these two hills, the clay being lower down. This dip shows conclusively that the clay does not run under the bowlders, as at first sight one would imagine. I do not mean the smaller bowlders of the upper gravel, which cover everything—only the glaciated stones.

Dr. Wood informs me that in an old excavation on Adams street, he saw the fossiliferous clays overlying the coarse drift for a considerable distance.

Again, along West Commercial street, the clay has been entirely removed, and where fossils once existed only the underlying bowlder clay is now found.

A section at the recent excavations at the race course shows the relative positions of the underlying drift, the fossiliferous sand and the superficial gravel. Those who desire to see these different members in contact should examine this locality. It is in these sands that Mr. Fuller found the clam or mussel shells lying in their native habitat. The siphon holes still remained—only sand had been silted into them from above. No fact could more clearly establish our view of the submergence of this part of the city.

The immense sand and clay plains to the east and west of us seem to have been deposited at the same time with the upper ferruginous gravel, *i.e.*, in the Terrace Epoch. The ferric condition of the iron about Portland indicates that the water was not deep at that time. No fossils have yet been found in this, nor in the terraces in the vicinity. As some of the bowlders are two feet in diameter, it would seem as if floating ice may have been an agent in their transportation. This pebble bed may be regarded partly as older than the clays of Cumberland and York counties, and partly as representing the same period, the stronger current having carried the coarse materials across to the shallow water over what are now the heights of Portland.

SLIDES.

Several slides have been described in the clays about Portland, particularly on the Presumpscot River.

The first one described (though not the oldest) occurred on the north bank of the Presumpscot River above Pride's bridge in 1831. An account of it was written by my father.

The next occurred in June, 1849, on the southern bank of Stroudwater River, about five miles from Portland. Estimated size, seven acres.

A third was described as occurring in November in 1868. This is above the slide of 1831, and much larger than any of the others.

This and some older ones, not known to history, have been fully described by Prof. E. S. Morse in the Proceedings of the Boston Society of Natural History for 1869. The following descriptions of them, and the very interesting changes induced by them in the bed of Presumpscot river, are copied from his paper :

There are traces of two slides of great magnitude, one of which has quite changed the former course of Presumpscot River. One of these slides occurred within the city limits of Portland, and has formed the abrupt embankment of Bramhall's Hill. Mr. C. B. Fuller and others have oftentimes remarked the evidences of a slide at this place. A few weeks since I made a special examination of this spot, and all the characteristics of a land slide are as plainly seen as if the slide occurred yesterday. On looking down from the embankment, the lateral ridges are seen to front the embankment only.

While examining this slide, my attention was attracted to the evidences of a river once running through Deering's Oaks and into Back Cove, showing clearly a broad river bed. As one passes over the Portland and Rochester railroad bridge, and examines the estuary across which the bridge is built, he cannot help remarking the evidences of the former presence of a river at that place, pouring into Back Cove. The traces of a terrace plainly exist. To the west of this region are scattered brickyards, and the whole surface is low and clayey, the surface sand being quite removed, and, as I believe, by a series of land slides. All these evidences prove that at one time a large body of water poured through this region, cutting out the long estuary called the "Fore River," producing the Bramhall slide, and at one time, on being turned aside through Deering's Oaks, assisting, at least, in wearing out the estuary called Back Cove. Certainly the Stroudwater River is too small a stream to have produced these results, since it has no natural reservoir, and drains but a small portion of country. My brother, who is quite thoroughly versed in the surface features of this region, concurs with me in the opinion that at one time the Presumpscot River flowed through these estuaries and originally formed the Fore River estuary.

An additional proof of this is seen in the traces of another slide of great magnitude, which we believe first turned the Presumpscot River into its present course. The outlet of this slide is occupied by the village of Saccarappa. It will be noticed that this slide occurred on the south side of the river, at the precise angle where it would be expected, and is of sufficient magnitude to have produced these results. And furthermore my brother has partly traced the old bed of the river, commencing south of Saccarappa and running through marshy land whose waters empty into Fore River.

As to the evidences of the Saccarappa slide, they are of the most positive character. In the first place the village rests upon a level plain of clay, and bordering this on all sides is an embankment from ten to twenty feet in height. The upper portion of this depression has always been called by the inhabitants "Warren's cellar," and indeed many have regarded this area as sunken land. In digging wells and sewers, trunks and branches of trees are met with at a depth of thirty feet from the surface. My brother sends me a birch stick, and says it was dug out at a depth of twelve feet from the surface, and about an eighth of a mile from the present bed of the river. A great many pieces of wood have been found in digging for a sewer; some loam has been found, but not much. I saw one leaf that was dug out; it was quite fresh. Another gentlemen informs me that he saw a number of leaves of the *Gaultheria procumbens*, which were still green, taken out at a depth of thirty feet. Some bones, presumed to be those of a bear, were also found.

I think there are evidences of another slide running to the south of the Saccarappa slide, and if this is the case, it will lend additional proof to the hypothesis that the river formerly had a southerly course.

I have rudely estimated the superficial area of the slide at one hundred and eighty-three acres.

Prof. Morse also informs me that since his paper was published, Mr. Jonas Hamilton, while superintending the excavations for the Portland and Ogdensburg railroad engine house, came across sticks, leaves and all the débris of a land slide, at a depth of fourteen feet. This excavation was made on the site of the supposed Bramhall slides. This is important evidence of the correctness of the views advanced by Mr. Morse.

The following is a list of all the Champlain fossils that have been found in the vicinity of Portland by C. B. Fuller.

VERTEBRATA.

Two species of whale.
Mallotus villosus.
Scales of Rays.
Teeth of Shark.

CRUSTACEA.

Cancer irroratus Say.
Hyas coarctata Leach.
Bernhardus Streblonyx Dana.
Balanus balanoides Linn.
" crenatus.
Cythera leioderma (Norman).
" lutea (Müll.).
" MacChesneyi (Brady and Crosskey).
" emarginata (Sars).
" concinna (Jones).
" Dawsoni (Brady).
" limicola (Norman).
" cuspidata (Brady and Crosskey).
" dunelmensis (Norman).
Cytheridea papillosa (Bosquet).
" cornea (Brady and Robertston).
" Sorbyana (Jones).
" Williamsoniana? Bosquet.
Loxoconcha granulata (Sars).
Xestoleberis depressa (Sars).
Cytherura nigrescens (Baird).
" Sarsii (Brady).
" cristata (Brady and Crosskey).
" striata (Sars).
" granulata (Brady & Crosskey).
" undata.
Cytheropteron latissimum (Norman).
" complanatum (Brady and Crosskey).
" nodosum (Brady).
Sclerochilus contortus (Norman).
Paradoxostoma variabile (Baird).

OTHER ARTICULATA.

Nereis.
Spirorbis spirellum.

MOLLUSCA.

Rhynchonella psittacea Gm.
Terebratulina septentrionalis Couth.
Ostrea borealis Lam.
Pecten Islandicus Ch.
Nucula antiqua Migh.
Yoldia pygmæa Mund.
" limatula Say.
Purpura lapillus Lam.
Tectura testudinalis Stm.
Leda glacialis Gray.
" tenuisulcata Couth.
Modiolaria nigra Gray.
Mytilus edulis Linn.
Cardium pinnatulum Ca.
Serripes Grœnlandicus, Ch.
Cryptodon Gouldii Phil.
Astarte semisulcata Moll.
" lactea Br. and Sow.
" striata Leach.
Mactra polynyma Stm.
Macoma subulosa Sprengl.
" fusca Say.
Solen ensis Linn.
Mya arenaria Linn.
" truncata Linn.
Cyrtodaria siliqua Sprengl.
Saxicava distorta Say.
" arctica Linn.
Thracia Conradi Couth.
" truncata Migh.
Lyonsia arenosa.
Pandora trilineata Say.
Pholas crispata Linn.
Bulla occulta Migh.
Cemoria noachina Linn.
Margarita cinerea Cent.
Aporrhais occidentale.
Natica pusilla Say.
" clausa Sw.
Buccinum Grœnlandicum.
" undatum Linn.
" ciliatum Fabr.
" Donovani Gray.
Trophon scalariformis Stm.
" clathratus Linn.
Bela harpularia.
" pleurotomaria Couth.
Fusus tornatus Gould.
" decemcostatus Say.
Trichotropis borealis Br. and Sw.
Lepralia hyalina Linn.
" variolosa.
" Bellii.
Tubulipora.
Membranipora.

RADIATA.

Echinarachinus parma Gray.
Echinus granulatus Say.

FORAMINIFERA.

Lagena sulcata.
" semistriata.
" substriata.
" gracilis.
" clavata.
" globosa.
Entosolenia squamosa.
" caudata.
" marginata.
Lingulina carinata.
Polymorphina lactea, var. compressa.
Nonionina scapha.
" striato-punctata.
Bulimina fusiformis.
" pupoides.
Triloculina tricarinata.
" oblonga.
Truncatulina lobatulina.
Quinqueloculina seminulum.
Dentalina subarcuata.
Textularia variabilis.
Sperilina foliacea.
Polystomella umbilicatula.
Patellina corrugata.
Globigerina bulloides.
Biloculina ringens.

Dr. Packard, in his able memoir, points out the distribution of the marine animals of our coast. The *Arctic* fauna is at present confined to the limits of North Greenland and about the pole at the isotherm of 0° C. This is succeeded by the Labrador or *Syrtensian* fauna extending now as far as the mouth of the Bay of Fundy. Our present New England or *Acadian* fauna extends from the southern limit of the Syrtensian to Cape Cod, and also appears in several places above the lower limit of the latter. The lower British Provinces exhibit one or the other of these faunas according to the presence of the polar current or the influence of the Gulf Stream.

The fauna of Portland in the Champlain corresponded to the Syrtensian, or the colder one. It seems to have extended as far south as Gloucester or Cape Ann.* The northern limit of the Acadian fauna during the same period was near Point Shirley, Winthrop, Mass. Thus the cold was sufficient to bring the boreal life two and a half degrees farther south than it is found at the present day.

Some have argued that the Champlain period is coeval with that of the glacier drift. I understand that the supposed superposition of bowlders at Portland and at Point Shirley is relied upon to sustain this view. I think I have shown clearly that all the bowlders over the fossiliferous deposits about Portland belong to the terrace period. I judge the same to be true at Point Shirley, since Stimpson states the dip of the sands to be eighteen degrees. Hence, though we cannot reduce the number of periods by uniting the drift and Champlain, we establish the reality of their difference; and thus contribute to the advancement of truth.

NOTE.—I will here take occasion to correct an error in a paper read last year at Dubuque upon "Recent Geological Discoveries among the White Mountains." Upon page 146, line eight from the bottom for Cambrian *read* Pre-Cambrian.

* Shaler, Proc. Boston Soc. Nat. Hist., vol. xi, p. 30.

On the Question "Do Snakes Swallow their Young?" By G. Brown Goode, of Washington, D. C.

It has long been a popular belief that the young of certain snakes seek temporary protection from danger by gliding down the open throat of the parent. This has been doubted by many naturalists, and the general disposition has been to class the belief among the popular superstitions. This paper is intended to sum up the evidence, which will show, it is hoped conclusively, that the popular idea is sustained by facts.

Allusions to this habit are found as early as the sixteenth century. In the "Faerie Queene," Spenser describes Error in these words:—

"But full of fire and greedy hardiment
The youthfull knight could not for ought be staide:
But forth unto the darksom hole he went,
And looked in: His glistring armor made
A litle glooming light, much like a shade;
By which he saw the ugly monster plaine,
Halfe like a serpent horribly displaide,
But th' other halfe did womans shape retaine,
Most lothsom, filthie, foule and full of vile disdaine.

"And, as she lay upon the durtie ground,
Her huge long taile her den all overspred,
Yet was in knots and many boughtes upwound,
Pointed with mortall sting. Of her there bred
A thousand yong ones which she dayly fed,
Sucking upon her poisnous dugs; each one
Of sundrie shapes, yet all ill-favored:
Soone as that uncouth light upon them shone,
Into her mouth they crept, and suddain all were gone.
* * * * * * * * * * *

"*She poured forth out of her hellish sinke*
Her fruitfull cursed spawne of serpents small,
Deformed monsters, fowle and blacke as inke
Which swarming all about his legs did crall,
And him encombred sore, but could not hurt at all.
* * * * * * * * * * *

"Her scattred brood, soone as their parent deare
They saw so rudely falling to the ground,
Groning full deadly all with troublous feare
Gathred themselves about her body round,
Weening their wonted entrance to have found
At her wide mouth; but, being there withstood,
They flocked all about her bleeding wound,
And sucked up their dying mothers bloud
Making her death their life, and eke her hurt their good."

["*The Faerie Queene*," 1590, *Book* 1, *Canto* 1, *vv.* 14, 15, 22 *and* 25.]

In Browne's "Vulgar Errors" may be found the following account of the Viper:—"For the young ones will upon any fright for protection run into the belly of the Dam; for then the old one receives them in at her mouth, which way, the fright being past, they will returne againe; which is a peculiar way of refuge, and though it seems strange is avowed by frequent experience and undeniable testimony."*

Gilbert White refers to the prevalent belief in this habit of the viper, and though rather inclined to favor it, he is evidently shaken in his faith by the adverse testimony of the London viper-catchers.†

M. Palisot de Beauvois, an eminent French naturalist, published in 1802 some very important observations on the rattlesnake, which will be quoted hereafter.

S. John Dunn Hunter, an early traveller in the United States, says:—"When alarmed, the young rattlesnakes, which are generally eight or ten in number, retreat into the mouth of the parent and reappear on its giving a contractile muscular token that the danger is past."‡ A few years later a long discussion occurred in the "Gardener's Chronicle" which, however, reached no satisfactory conclusion.

In a note to the eighth edition of "Selborne," Sir William Jardine says:—"The question remains, we believe nearly as it did in White's time. The supposed habit is so much at variance with what we know of the general manners and instincts of animals, that without *undoubted proof* of its occurrence we are inclined to consider it as a popular delusion."§

In 1865 Mr. M. C. Cooke, editor of "Science Gossip," made a strong argument in the affirmative.‖

Mr. F. W. Putnam published in the year 1869¶ a very thorough

*"Pseudodoxia Epidemica: or, Enquiries into very many received Tenents and commonly presumed Truths. By Thomas Browne, Dr. of Physick." London, 1646, p. 143.

†"The Natural History of Selborne," 1789, Series 1, letter xvii; Series 2, letter xxxi.

‡"Memoirs of a Captivity among the Indians of North America," London, 1823, p. 170; and "North American Review," 1826, pp. 51, 95-107.

§"Natural History of Selborne." London, 1853, p. 58.

‖"Our Reptiles," London, 1865, p. 58.

¶"American Naturalist," vol. ii, p. 173. To this article, which first interested me in the subject, I owe many valuable suggestions. I am also indebted to Prof. Baird, to Prof. Theo. Gill, to Prof. W. N. Rice of Middletown and to Mr. James Simson of New York, who have called my attention to facts which would otherwise have escaped my notice.

discussion of the question.* He speaks of it as still unsettled and, though sympathizing fully with Mr. Cooke, asks for additional proof.

During the past year an animated discussion has been carried on in the London "Land and Water." Mr. James Simson and others have argued for the affirmative but Frank Buckland, the editor, classes the belief among the numerous popular delusions and persistently refuses to believe until he or some other naturalist has personally investigated the subject.

The feeling of the majority of naturalists at the present time seems to be well expressed in these words:—"The cumulative testimony of many witnesses would compel us to receive this supposed habit as an established fact, did not experience warn us of the extreme liability of untrained observers to be misled by preconceived opinions. The fact that no competent naturalist has found young vipers in the stomach or œsophagus of the mother raises a strong presumption, on the doctrine of probabilities, of its being a mere delusion. The habit moreover would be contrary to the ordinary laws of animal instinct which lead both parent and offspring to adopt the best available means for the preservation of the race.*

Theorizing upon this question has proved useless, and it is obvious that it can only be settled by the statements of persons who have seen the act. Believing that none would be so likely to supply the desired facts as those whose vocation brings them into daily contact with snakes in their native haunts, I wrote a short note to Mr. Orange Judd, Editor of the "American Agriculturist," which he kindly inserted in the issue of that magazine for February, 1873.

As a result over eighty letters were received, from persons in twenty-four states and provinces, almost every one containing valuable evidence. Many of the writers seem indignant that a fact so well known to them should be questioned. On the depositions of these witnesses, together with those collected by diligent personal inquiry, the case must rest.

A farmer living in Mechanicsburg, Ohio, writes:—"In 1835 I saw on the bank of Deer Creek a large water-snake. I procured a pole for the purpose of killing her. One stroke slightly wounded her and she immediately made for the water; after she had swam

*"D" (Yorktown, Virginia) in "Land and Water," xv, p. 78, Feb. 1, 1873.

about her length she wheeled, placing her under jaw just out of the edge of the water, then opening her mouth to the fullest extent. Some dozen young snakes, three to four inches long then seemed to run or rather swim down her throat, after which she clumsily turned in search of a hiding place. I opened her and found about twenty living young snakes, two or three seven or eight inches long."

A gentleman in Georgetown, S. C., writes:—"I had for several days noticed a very large moccason coiled around the limb of a small tree near the pond. I concluded to capture it and accordingly procured a large rabbit and placed it some way up from the pond to toll her away from the water. She soon came down and disappeared under a large log; when next seen she was near the bait, having traced it along the log on its opposite side. When she had nearly swallowed the bait we made an advance; quickly disgorging it she gave a shrill whistling noise, and five young snakes ran from under the log and ran down the throat of the old one. We cut off her head and found the five young, which made efforts to get away."

A farmer in Rosendale, N. Y., writes:—"I was one day mowing and coming close to a smooth flat rock, I thought I saw as many as a dozen snakes on it. I ran for a fork which was standing within a few yards and when I came back there was only one snake on the rock. I struck it on the back and seven snakes ran out of the mouth."

A letter from Chesterfield, N. H., says:—"I saw a striped snake on the hillside, and noticed something moving about her head, and counted twenty little snakes, from one and a half to two inches long. I made a move and the old one opened her mouth and they went in out of sight. I stepped back and waited and in a few moments they began to come out. Then I made for the old snake and killed her and forced out several."

A farmer in Newburyport, Mass., writes:—"Riding through a large corn field, in the centre of which was a large shelving rock I observed on the top a curious commotion, but on near approach found nothing. My curiosity was excited, and the next day I repaired to the spot very cautiously, and on the top of the rock saw an enormous striped snake sunning herself, surrounded by a bevy of young four to six inches long. After viewing them to my satisfaction I made a demonstration, and to my surprise the

old snake opened her mouth very wide, the little snakes ran down her throat and then she disappeared in the shelving rock. I repeated the experiment a number of days to the same effect."

The total number of testimonies in my possession is one hundred and twenty. Sixty-seven witnesses saw the young snakes enter the parent's mouth; twenty-two of these heard the young warned by a whistle or hiss or click or sound of the rattles; five were considerate enough to wait and see them reappear when danger seemed over; one seeing the act repeated on several days.

Three saw young snakes coming out of a large one's mouth, and not having seen them enter were naturally much astonished. Five struck the parent and saw the young rush from its mouth; eighteen saw the young shaken out by dogs or running from the mouth of the dead parent. Thirty-six of those who saw the young enter the parent's mouth, found them living within its body. Only twenty of the sixty-seven allowed the poor, affectionate parent to escape. Thirty-three who did not see the young enter, found them living within the parent's body. Testimony of this character concerning the ovo-viviparous species is, however, to say the least, dubious.

It may be objected that these are the testimonies of laymen, of untrained observers, of those who might be influenced in their observations by their prejudices. I reply that the letters are from a class of well-informed farmers, mechanics and business men, intelligent readers of a practical agricultural magazine. The act of swallowing the young is of such a character as to admit little room for error in the observations, and I find that, as a general rule, opinions on the subject are current only among those who have had it brought to their notice by their own experience or that of their friends. Due weight should be given to the wide distribution of the witnesses, and the remarkable concurrence in their statements.

Let us not, however, trust entirely to the statements of the untrained observer. Says Mr. Cooke:—"Clergymen, naturalists, men of science and repute, in common with those who make no profession of learning, have combined in this belief."* We add the statements of gentlemen, the accuracy of whose observations in other departments of natural history would surely not be doubted. Prof. Sydney I. Smith, of the Sheffield Scientific School, saw a

*"Our Reptiles," p. 76.

ribbon-snake (*Eutænia saurita*), about two feet long, accompanied by two young ones of three or four inches; on a hiss from the parent they disappeared down its throat. The parent was killed and two ran out of the mouth, while a third was found alive in the body. Dr. Edward Palmer, a well known traveller and collector, assures me that when in Paraguay with the "Waterwitch" expedition, he saw seven young rattlesnakes (*Caudisona terrifica*) run into their parent's mouth. After it was killed they all ran out. These snakes, parent and brood, are preserved in the U. S. National Museum, Washington.

Rev. Chauncey L. Loomis, M.D., of Middletown, Conn., a keen and enthusiastic observer, saw a black snake (*Coluber Alleghaniensis?*) open its mouth, allow seven young ones to enter and then glide away.

D. L. Phares, M.D., of Woodville, Miss., writes:—"A few years ago a gentleman, directing some hands at work on my lawn, heard a low, blowing noise, and on looking saw a large water moccason (*Toxicophis piscivorus*, I believe) and a large number of young hurrying to her head and disappearing so rapidly that he first thought they ran under her. He soon discovered that they went into her slightly opened mouth, which was held close to the ground till they had all entered. She then attempted to escape, but was cut in two with a hoe. We took from her a large number of young, eight or ten inches long."

I might take from Mr. Cooke's work several statements equally to the point. I quote from the "Zoologist" a note concerning the scaly lizard (*Zootoca vivipara*), which has an important bearing upon the question. Says the editor, Mr. Newman:—"My late lamented friend, William Christy, Jr., found a fine specimen of the common scaly lizard with two young ones; taking an interest in everything relating to natural history, he put them into a small pocket vasculum to bring home, but when he next opened the vasculum the young ones had disappeared, and the belly of the parent was greatly distended; he concluded she had devoured her own offspring. At night the vasculum was laid on a table and the lizard was therefore at rest; in the morning the young ones had reappeared and the mother was as lean as at first."*

Mr. Putnam has kindly put into my hands a note from Thomas Meehan, of Philadelphia, containing strong affirmative testimony

* "The Zoologist," p. 2269.

in the case of the English viper as observed by him in the Isle of Wight; also a note from Herman Strecker of Reading, Pa., who says:—"Some years ago I came across a garter snake (*Eutænia saurita*) with some young ones near her. Soon as she perceived me she hissed and the young ones jumped down her throat, and glided beneath a stone heap. Another time I caught a snake of the same species, but as I thought of immense size, which I took home and put in a cage; on going to look at her some short time afterwards I discovered a great number of young ones (about thirty if I recollect rightly) and whilst I was still looking at the sudden increase, two more crept out of the old one's mouth, and finally after a little while a third one did likewise."

Prof. C. F. Brackett, of Princeton College, sends me a note which, besides throwing light upon the question under consideration, gives a very interesting instance of hereditary instinct: he writes:—"About twenty-five years ago I saw the following things. A workman who was mowing in my father's hay-field came upon a moist, moss-grown knoll, and his scythe cleft off a portion of the thick moss and sphagnum and revealed several (at least a dozen, I should say) small soft bodies which he declared to be snakes' eggs. I at that time having no knowledge of such matters was incredulous, and proceeded to tear one of them open, when, to my surprise, there appeared a small, perfectly formed milk adder, which immediately assumed a pugnacious attitude, and brandished its tongue as defiantly as an old snake would have done. Other eggs were torn open with like results. Soon the old snake appeared and after endeavoring, apparently to encourage the young family, thus suddenly initiated into the world, it put its mouth down to the ground, and every one that had been liberated from the egg voluntarily and hastily disappeared within the abdomen of the old one (mother?). Last of all I put the point of a pitchfork through the old snake and fulfilled the scriptural injunction of bruising its head, when with a pocket knife I opened the abdomen and found the young ones still active."

The snake referred to by Prof. Brackett is apparently the common milk-snake (*Ophibolus triangulum*).

Col. Nicolas Pike, late U. S. Consul at the Mauritius, assures me that he has seen the garter-snake (*Eutænia sirtalis*) afford its young family temporary protection in its throat, from which they were soon noticed to emerge.

Our last witness is one who appears to have been overlooked throughout this discussion, one whose statement, it would seem, ought of itself to have decided the question long ago. M. Palisot de Beauvois, an eminent French naturalist, member of the Institute and Councillor of the University of Paris, thus details an observation made near the close of the last century:—"When making my first excursion into the Cherokee country,* I happened, while botanizing, to see a rattlesnake in my path. I approached as softly as possible, but, just as I was about to strike, imagine my surprise to see it, after sounding its rattle, open a very large mouth and receive into it five little serpents, each about the size of a goose-quill. Astonished at this singular spectacle I retired some distance and hid behind a tree. After some minutes, the animal, believing itself out of danger, again opened its mouth and allowed the little ones to escape. I advanced, the little ones retreated to their stronghold, and the mother, carrying her precious treasure, disappeared among the underbrush where I was not able to find her."†

We have the opinion of Dr. Jeffries Wyman,‡ Prof. Gill and other physiologists, that there is no reason why the young snakes may not live for a time within the parent. It would be very difficult to smother a reptile, even in such close quarters, and lizards, toads and snakes have often been rescued, unharmed, after a sojourn in a snake's stomach. It is a well known fact that living tissues are acted upon very feebly by the gastric juice.§

The supposition that the serpents swallow their young for food is manifestly absurd, for the act is purely voluntary with the young snakes. If the habit is not protective in its design, it must be destructive to a degree that will in time exterminate the species which practise it.

An analogous case is found among certain South American fishes of the genera *Geophagus*, *Arius* and *Bagrus*, the males carrying the eggs in their mouths, depositing them in places of safety and removing them on the approach of danger.‖

* The Cherokees were at this time joint-owners of the states of Tennessee, Mississippi and Alabama, with the western portions of North Carolina and Georgia.

† Beauvois, "Observations sur les Serpens" in Daudin's "Histoire Naturelle, Générale et Particulière des Reptiles" Paris, An. Rep. xi (1803), vol. v, p. 65.

‡ "American Naturalist," vol. ii, p. 137.

§ Flint's "Physiology of Man," New York, 1871, vol. ii, pp. 275–282.

‖ Wyman, "Proceedings of the Boston Society of Natural History," vol. vi, p. 328, 1858. "American Journal of Science and Arts," vol. xxvii, 1859, p. 11. Günther "Catalogue of the Fishes in the British Museum," vol. v, 1864, p. 173.

I have been told of two instances where a large snake was found to contain one of smaller size, which in its turn had within it a number still more diminutive. This may be easily explained by supposing the parent snake, after affording the usual protection to its young brood, to have been swallowed by some hungry reptile of larger size.

The American Indians seem to have had some knowledge of this peculiar habit of the rattlesnake. Among the many legends collected by Maj. J. W. Powell, U. S. Geologist, in his researches among the Pai Utes, is one giving the origin of the echo. An old sorceress was suspected of wrong doing and was pursued by her enemies until in desperation she sought aid from her grandfather, "Takoa," the rattlesnake. His only resource was to open his mouth and allow the old witch to crawl in out of sight and out of danger. She was so well pleased with her safe retreat that she could not be induced to leave it, so the rattlesnake had to crawl out of his skin and leave her within. And there, say the Pai Utes, she remains to this day, and when any one calls she mockingly repeats their words from her hiding place in the cast off snake-skin.

This curious tradition, even if it cannot be counted as evidence, shows in an interesting way the wide prevalence of this belief.

There is much need of other observations, to determine what species of American snakes have this singular habit. Thirty-four of the observations relate to *Eutænia;* the habit is probably shared by all the species, but is only well attested for the garter snake (*Eutænia sirtalis*) and the ribbon-snake (*Eutænia saurita*). Seventeen refer to the water-snake (*Tropidonotus sipedon*). Nine refer to the banded rattlesnake (*Caudisona horrida*), two to the copperhead (*Ancistrodon contortrix*), three to the moccason (*Ancistrodon piscivorus*) and one to the massasauga (*Crotalus tergeminus*). Does the habit extend throughout the *Crotalidæ?* One instance is given for the blowing-adder (*Heterodon platyrhinos*) and three for the mountain black snake (*Coluber Alleghaniensis*). Six relate to the so-called "black snake," but this name is too indefinite. With all deference to Mr. Buckland, I believe the case of the viper (*Pelias berus*) to be settled, as well as that of *Zootoca.* Whether the male snake ever protects the young in this way has not been observed.

It is a noteworthy fact, which may or may not prove an im-

portant one, that the snakes mentioned above are all ovo-viviparous with the exception of Ophibolus. There is nothing to indicate that the habit is shared by the oviparous snakes of the genera *Liopeltis*, *Cyclophis*, *Storeria*, *Diadophis*, and *Pityophis*. The case of *Bascanion*, which is oviparous, is still quite problematical, and it remains to be shown whether the "black snake" of my correspondents is *Coluber Alleghaniensis*, or *Bascanion constrictor*. Mr. Gosse gives facts which make it seem quite probable that the Jamaica boa (*Chilabothrus inornatus*) may share the habit.*

The breeding habits of North American snakes deserve careful investigation, as they are totally unknown in more than twenty-five of the genera.

Circles of Deposition in American Sedimentary Rocks. By J. S. Newberry, of New York.

At the meeting of the American Association for the Advancement of Science, held at Newport, R. I., in 1860, having then just returned from the far West, where I had spent several years in geological explorations, I communicated to the Association the results of a study of the Cretaceous deposits in the area lying between Eastern Kansas and Indianola, Texas, on the east, and the Colorado River on the west. In this region I found the base of the Cretaceous system composed of coarse sandstone, sometimes a conglomerate, containing everywhere the impressions of Angiospermous leaves, and in many places heavy beds of lignite; the equivalent of Meek and Hayden's No. 1. Above this lies a laminated, impure limestone, containing as characteristic fossils, *Ionoceramus problematicus*, *Gryphœa Pitcheri*, *Scaphites larvæformis*, *Ammonites percarinatus*, etc., the series which corresponds to Meek and Hayden's No. 2 and No. 3. Above the last mentioned

* "A Naturalist's Sojourn in Jamaica," London, 1851. pp. 318–23, 501. There is reason to believe that some of the Eutænias, like the scaly lizard (*Zootoca vipara*) are in some instances oviparous, in others ovo-viviparous, and this point should be kept in mind in making observations upon that and other genera.

group is a heavy mass of calcareous strata, abounding in *Ammonites*, *Scaphites*, and other well known and characteristic Cretaceous mollusks. The fourth member of the series, best developed in and about the Rocky mountains, is formed by a group of calcareous sandstones and shales, with impressions of plants, sheets of lignite and some mollusks, such as characterize Meek and Hayden's No. 4 and No. 5. From this sequence of strata, I read the history of a submergence of the Triassic continent and an invasion of the sea which resulted, first, in the formation of a wide-spread sheet of beach sand and gravel, containing the trunks of trees, which had grown on a land surface in the vicinity of the localities where they are found. Second, a mixture of mechanical and organic sediments, constituting the off-shore deposits of the invading sea. Third, a great calcareous mass, the organic sediments of the open sea during the long continued period of greatest submergence.

Since the date of the presentation of the paper referred to above, my attention has been particularly directed to the study of the palæozoic formations of the valley of the Mississippi. The result of such study has been to lead me to believe that each of the great palæozoic systems represented on the eastern half of our continent, may be resolved into a circle of deposits similar in general character to that of the Cretaceous system. These views have been briefly set forth in the first volume of the Final Report of the Geological Survey of Ohio, but I now propose to present them somewhat more fully and connectedly for the consideration of the members of the Association.

Before attempting to analyze the composition of our different systems of sedimentary rocks, it is important that a few preliminary facts and considerations should be stated, as they constitute the real premises from which our conclusions are to be drawn.

First: *the sea is the mother of continents.* It is now universally conceded that with the exception of certain local fresh-water beds, all stratified rocks are sediments deposited from the waters of the ocean, and that wherever we now find these sediments we have in them proof that the sea has reached and flowed over such localities.

Second: the composition of the geological column proves that repeated submergences of our own and other continents have taken place, and shows that what we call *terra firma* is rather a

type of instability. Elevations and depressions of the sea level have been constantly going on in past ages, and are undoubtedly progressing at the present time, but so slowly that in the brief period of human life, or even of human history, the changes effected by them attract little attention.

Third: the manner in which sedimentary strata are formed, and the action of the sea upon its shores, will be best understood by an examination of what is now going on upon our own and other coasts. By the action of frost and sun, ice, rain and rivers, all land surfaces are being constantly worn away, and the comminuted and dissolved materials are carried off to be deposited in the oceanic basin into which the rivers discharge themselves. Along the coast lines the shore-waves are constantly eating away the barriers against which they break. Nothing can resist their mechanical force, solvent power and incessant activity. The hardest rocks are in time ground up and comminuted by them, and the resultant materials are distributed along the ocean bed by the undertow according to their specific gravity or the minuteness of their trituration.*

The wash of the land which forms the mechanical or fragmental sediments, reaches but a limited distance from the shore. In the depths of the ocean organic sediments are accumulating, which are derived from the hard parts of the various organic forms inhabiting the open sea. This is the "ooze" brought up in all deep sea soundings, and is mainly composed of the carbonate of lime, as it is for the most part made up of the shells of mollusks and foraminifera which have the power of drawing this substance from the ocean waters. On shores lined with coral reefs or composed of limestone rocks, even the mechanical deposits are calcareous. Coral-lined shores, too, are often increasing, as here the accumulation of material through the agency of polypes and other organisms, is more rapid than its waste by the mechanical or solvent power of the shore waves. These exceptions do not, however, affect the validity of the general rule which is here enunciated.

*The power of water or air in motion to transport any homogeneous material is measured directly by the size of its particles or masses. According to the law of the ratio of the surface to solidity on spheres of different diameters, the ratio of surface to mass increases as the diameter is diminished. The transporting medium acts on the surface and its power increases as the relative surface increases. This accounts for the different transporting power of water on boulders, gravel, sand and clay, and shows why iron-filings are carried by the wind and cannon balls are not.

We see, then, that the sediments deposited on every shore form two areas or belts, viz.: that nearest the land, where they are mechanical and graduate in fineness from the shore line to deep water; and an area beyond the wash of the land, where calcareous and organic sediments are alone thrown down. Necessarily along the line of the junction of these areas the sediments will be of a mixed character. The map of the sea bottom off our Atlantic coast, made by Count Pourtales, beautifully illustrates the statements that have been made. On this map is shown a broad belt skirting the shore, where the sediment is mainly sand. Outside of this, a parallel belt, over which the sediments are calcareous.

Fourth: if now an invasion of the continent by the ocean were to take place, such as have repeatedly occurred in past ages, the following sequence of phenomena would necessarily ensue. All portions of its surface must in succession be subjected to the action of the shore waves. By their agency the solid and superficial materials lying above the sea level would be ground up and washed away, the greater part forming mechanical sediments and being distributed according to the law of gravitation, the soluble portions taken into solution and carried out to impregnate the ocean waters, and to supply material to the myriads of organisms that have the power to draw from this solution their solid parts. In the advance inland of the shore line the first deposit from the sea would be an unbroken sheet of sea-beach, composed of coarse sand and gravel, containing trunks, branches and leaves of trees, and other débris of the land. This sheet would cover the rocky substructure of all portions of the continent brought beneath the ocean. Over these coarser materials would be deposited a sheet of finer mechanical sediments, principally clay, laid down just in the rear of the advancing beach, and finally over all a sheet of greater or less thickness of calcareous material, destined to form limestone when consolidated, the legitimate and only deposit made from the waters of the open ocean.

Fifth: in the slow retreat of the sea, at the end of a period of submergence, the land would be again covered with vegetation, creeping down from the highlands, if any such had remained uncovered; where complete submergence had taken place, by the importation of a new flora, as the coral islands have been clothed. The receding sea would receive the drainage from the land—for

the most part fine mechanical material,—and mingling this with the new calcareous deposits and the shore wash of older organic sediments would leave behind it a sheet of mixed material, mechanical and organic, as the last product of this submergence.

Sixth: when the sheets of sediment, the genesis of which we have been considering, were consolidated to rock—as they would generally soon be by pressure or by siliceous and calcareous solutions,—if they should be penetrated and examined they would be found to consist of, 1st, superficial materials, the product of surface erosion and washing; 2d, a mixed mechanical and calcareous stratum containing shallow-water, marine or estuary organisms; 3d, a limestone containing the remains of all the inhabitants of the ocean which possessed shells or other hard parts; 4th, a sheet or sheets of mechanical materials, once clay, sand and gravel, now consolidated into shale, sandstone and conglomerate. All these strata would rest upon the rocky foundations of the continent, the result of a previous submergence and representing an earlier geological age. The later strata would be found laid down over all the irregularities of the older surface; and between the older and more recent rocks a break or want of continuity would be discovered and generally a want of harmony in their lines of deposition.

Seventh: another invasion of the sea would leave similar records of a similar history, with this difference only, that the tribes of animals and plants inhabiting the land and water would, in the lapse of ages, have experienced marked changes. Perhaps in the interval the old fauna and flora would have entirely disappeared; so that the new sediments would include only relics of new races.

Eighth: in the foregoing sketch an uninterrupted sequence of phenomena has been alone considered. When, however, during the invasion or recession of the sea the uniformity of the elevation or depression should be broken and oscillations of level ensue, the record would be considerably complicated, and we should have local alternations of land, shore and sea conditions, which would give us smaller circles within the great ones, and thin sheets of mechanical or organic sediments interstratified in any one of the great members of the series.

Having thus briefly reviewed the conditions under which the different kinds of sedimentary strata are deposited, and having

traced out the circle of deposits that would necessarily be formed in the submergence of a continent by the sea and the subsequent retreat of that sea, let us see how far we can trace a parallelism between the series of phenomena described and those presented by the strata composing our different geological systems.

In the United States the geological column is composed of the following elements: at the base we have the Laurentian and Huronian groups, forming the Eozoic system, and composed of crystalline rocks, once limestones, sandstones, shales, etc., but now much metamorphosed and disturbed, and their fossils obliterated. These are the oldest rocks known, and when elevated they formed what we may call the Eozoic continent. Upon the Eozoic rocks we find, between the Atlantic and the Mississippi, the various strata which compose the palæozoic systems, the Lower Silurian, Upper Silurian, Devonian and Carboniferous. Of these the Lower Silurian consists, beginning at the base, of, 1st, the *Potsdam sandstone*, generally a coarse, mechanical shore deposit; 2d, the *Calciferous sand-rock*, a mixed mechanical and organic sediment, more sandy towards the east, more calcareous and magnesian towards the west, which we must class as an off-shore deposit; 3rd, the Trenton limestone group, consisting of the Chazy, Bird's-eye, Black River and Trenton limestones; a great calcareous mass full of marine organisms, including representatives of the subkingdoms of the Protozoa, Radiata, Mollusca and Articulata, but no remains of Vertebrates. This is plainly an open sea deposit; the different members of the limestone group representing epochal subdivisions of one great life period, and one great chapter in the history of the first submergence of the Eozoic continent, that of the long continued prevalence of marine conditions over all the area where this formation is now found; 4th, the *Hudson group*, consisting of shales and impure limestones, mixed mechanical and organic sediments, the deposits of a shallowing and retreating sea. This member completes the circle of the deposits of the Lower Silurian and ends the history of the first submergence of the Eozoic continent.

The Upper Silurian system is composed at base of the *Medina sandstone*, locally a conglomerate to which the term Oneida has been applied, a shore deposit corresponding to the Potsdam; above this, the *Clinton group*, which is composed of limestones and shales, and the peculiar Clinton iron ore, evidently an off-

shore deposit; still higher, the *Niagara group;* below, shaly, and showing a shallowing of the Clinton sea; above, a great and wide-spread mass corresponding in position to the Trenton group of the Lower Silurian circle. This abounds in the remains of marine fossils, and is evidently the sediment of the open sea of the Upper Silurian age. The inhabitants of this sea, judging from the remains they have left behind them, were generally distinct from those of the older Trenton sea, although a few species seem to have been common to both. In America we have as yet found no traces of Vertebrates in the sediments of the Upper Silurian sea, but in Europe some remains of fishes have been found at this horizon. The Niagara limestone is overlaid by the *Salina* and *Helderberg* groups. Of these the Salina is evidently the deposit from a shallow and circumscribed basin like the Caspian, Dead sea or Salt Lake, where the salts held in solution, chloride of sodium, sulphate of lime, etc., were precipitated by evaporation, with a considerable portion of introduced earthy matter. The *Water-lime group*, which overlies the Salina and forms the base of the Helderberg series, is an earthy magnesian limestone. It is best developed towards the west, while the Helderberg proper is thickest towards the east, showing an unequal tilting of the shallow oceanic basin in which these strata were deposited, and a gradual emergence of the land on the north and west. Notwithstanding some local irregularities of deposition, the Helderberg group corresponds in character and position with the Hudson of the Lower Silurian and completes the Upper Silurian series by a return to land conditions.

The two circles of deposition which have been described are grouped together under the term Silurian, but as each is complete in itself and is a record of a totally distinct round of changes, and as the fauna of the two systems have almost nothing in common, it will, I think, be generally conceded that it was an error to combine them under one name; and since they are as distinctly separated as are the subsequently formed systems, each of which has an independent title, that it would have been better to designate the Silurian systems by totally distinct names.*

The Devonian system is composed, at the base, of the *Oriskany sandstone*, a shore deposit, above which we have the *Schoharie grit*,

*The interests of science and the cause of justice would both be served if we could agree to call the Lower Silurian by Prof. Sedgwick's name. *Cambrian*, leaving Murchison adequate honor in retaining his names, *Silurian* and *Devonian*, for the overlying systems.

a mixed mechanical and organic, arenaceous and calcareous, sediment, an off-shore formation; then the *Corniferous group*, a wide-spread sheet of magnesian limestones, containing little earthy matter, abounding in marine fossils, and plainly the deposit of an open sea. In this sea the fauna was, with the exception of two or three surviving species, totally distinct from that which preceded it; its chief characteristic being its various genera and species of fishes, many of which attained large size. The Corniferous limestone is overlaid by the *Hamilton group*, a calcareo-argillaceous mass consisting of alternations of shales and limestones, the shales thicker and more sandy at the east, limestone predominating at the west. Including the Genesee and Huron shales, which properly belong to it, the Hamilton group presents all the main features, in character and position, of the Helderberg and Hudson, and is, as I believe, composed of the sediments of an oscillating, but on the whole shallowing and retreating sea.

In all our works on geology the Portage, Chemung and Catskill formations are included in the Devonian system, but in my judgment it would be better to consider the *Portage sandstones*—the upper half of the Portage group—as the true base of the Carboniferous system. Drawing the line at this point, we find the Portage and Chemung forming an indivisible mass of mechanical sediments, which, both in fossils and lithological characters, contrast strongly with the underlying Hamilton, and is evidently the record of a new era in the geological history of the continent. This new group I have called the *Erie*, and I think it will be found to belong, both by its fossils and its physical relations, rather with the Carboniferous than the Devonian system, and thus to correspond with the Potsdam, Medina and Oriskany below. The Catskill is a local and ill defined deposit which will probably prove to be the sediment of a fresh-water basin or a circumscribed bay in the land which formed the shore of the Carboniferous sea.

Above the Erie and Catskill we have the *Waverly group*, the equivalent of the "Vespertine" and "Umbral" of Rogers, a mixed mechanical and organic, shore and off-shore deposit. Above this, and spreading over a great area towards the west, we find the *Carboniferous limestone*, which is plainly, as I have elsewhere shown,* the sediment of an open sea caused by the gradual submergence of the central and western portions of the continent.

* Geological Survey of Ohio, vol. 1, p. 73.

Overlying the carboniferous limestone are the Carboniferous conglomerate and the Coal Measures, both of which should, however, be grouped together as the product of one epoch, and that of continental elevation, though of local subsidence. During the deposition of the Coal Measures there were numerous alternations of elevation and subsidence, the latter strongly marked in the coal basins proper, but as a whole it was a time of prevailing and increasing land conditions, so firmly established at the close of the Coal Measure epoch, that in the region between the Atlantic and Mississippi there has been no general submergence since.

PLACE OF DEPOSIT.	KIND OF SEDIMENT.	CORRESPONDING CIRCLES OF DEPOSITION.			
Retreating Sea.	Mixed.	Hudson.	Helderberg.	Hamilton.	Coal Measures.
Open Sea.	Organic.	Trenton.	Niagara.	Corniferous.	Carboniferous Limestone.
Off Shore.	Mixed.	Calciferous.	Clinton.	Schoharie.	Waverly.
Shore.	Mechanical.	Potsdam.	Medina.	Oriskany.	Erie.

In the foregoing table the classification of the sediments which compose our palæozoic systems is such as I think may be found illustrated in many localities, and yet I should be unwarranted in claiming that all the elements in the circles of deposition described above can be recognized in the products of every continental submergence. It will probably clarify and simplify the theory now advanced, to claim as the *essential* elements of each circle of deposition resulting from an invasion of the sea, but three distinct sheets of sediments, viz.: the mechanical, organic and mixed, the products respectively of the advancing, abiding and retreating sea. The lines of separation between these are more or less sharply defined according to the rapidity of the submergence, and the nature of the materials acted upon by the shore waves.

Although the views advanced on the preceding pages have grown up from independent observations and were substantially embodied in the analysis of the Cretaceous and Triassic groups

of the far West, presented by me to the American Association in 1860, it is also true that "Circles of Deposition" in sedimentary rocks have attracted the attention of many other geologists. Sir Roderick Murchison, in his description of the Permian of Russia, alludes to the fact that it consists of a trinity of strata—mechanical sediments above and below, separated by a limestone—just as in the Trias, which is composed of the Bunter, the Muschelkalk and the Keuper. Mr. Edward Hull has written quite largely upon the subject,* proposing an arrangement of all the sedimentary strata in ternary series, a limestone being the centre of each trinity. In our own country the similarity in lithological character in the elements composing our different geological systems has been referred to by Profs. Eaton, Hall, Hunt† and Dawson.‡ Although constructed quite independently, the Circles of Deposition traced out by Hunt, Dawson and myself agree in all their more important features, and they may therefore be accepted as being in the main accurate representations of real facts in nature. My reading of these facts is, however, somewhat different from that offered by any of my colaborers. From the striking resemblance presented by the circles of deposition described, it is evident that they are the product of a common cause or series of causes; in other words, that they are different expressions of one law (order of sequence) in the deposition of sediments. To define and explain that law is the chief object of this paper.

In his description of the circles of deposition which he enumerates, Mr. Hull with great sagacity points out many interesting and suggestive features in their structure, such as their being composed of mechanical sediments above and below, separated by a limestone; in the lateral reach of the strata the preponderance of limestone in one direction, of mechanical sediments in the other, etc., etc., but he offers no suggestion as to the causes by which these systematic phenomena were produced, except to designate the mechanical sediments as the product of "epochs of land prevalence with movements;" the calcareous sediments, the product of "sea prevalence with quiescence."

*Journal of the Geological Society of London, vol. xviii, p. 132. Geological Magazine, vol. v, p. 143. Quarterly Journal of Science, vol. vi, p. 353.

†Geology of Canada, 1863, p. 127. American Journal of Science (2 se.), vol. xxxv, p. 167.

‡Journal of the Geological Society of London, vol. xxii, p. 103. Acadian Geology, p. 135.

Prof. Dawson's circles are composed of four elements each, as follows:

4. "Shallow, subsiding marine area, filling up with sediment.
3. "Elevation, followed by slow subsidence, land-surfaces, etc.
2. "Marine conditions; formation of limestones, etc.
1. "Subsidence; disturbances; deposition of coarse sediments."

As I have remarked on a preceding page, we may locally have four or even more elements in a circle, but three are all that can be insisted upon as the necessary effects of the cause to which I attribute the phenomena we discover. That cause I claim to be, as will be remembered, an invasion of the sea and submergence of the land in each geological age, the spread of mechanical sediments formed by shore waves over most of the area invaded; then the deposition on this sheet of mechanical material of a mass of greater or less thickness of calcareous sediments, the record of the quiet occupancy of the submerged area by the open sea; and finally, mixed calcareous and mechanical sediments deposited by the shallowing and retreating sea.

In many instances we have circles within circles, as in the Niagara period with its several epochs, the Hamilton, the Coal Measures, etc. These subordinate circles are proof of oscillations of level, *i.e.*, alternations of shore and sea conditions. It is scarcely necessary to say to a geologist that in passing from the area of permanent land (land that was not submerged in any inundation), to the area of permanent sea (the area beyond the reach of the wash of the land, where neither shore nor off-shore deposits were laid down, but only an unbroken series of limestones), we shall get different sections at different points of observation, the strata becoming more calcareous in one direction, and more siliceous in the other. Hence we find the mechanical strata diminishing in force and finally thinning out completely as we recede from the old coast formed by the Canadian highlands, the Adirondacks and the Blue Ridge, toward the oceanic basin on the south and west. So on the eastern side of the continent the Palæozoic strata are nearly all calcareous in the Gaspé district. It should be borne in mind also, as has been suggested, that local circumstances materially modified the record made by the invasion of the land by the sea. In some places the portion submerged furnished abundant material out of which gravel, sand and clay

beds were formed. In other localities the shore waves beat on abrupt declivities of hard rock, perhaps in sheltered situations where little force was developed and little sediment produced. Here during the period of greatest submergence, limestone strata were deposited directly upon the clean, washed rocks, with no intervening sea beach. In the third place where the shore was formed of upheaved strata which were all calcareous, or where it was lined with coral reefs, even the mechanical sediments were calcareous.

In some instances we have indisputable records of the *progressive* invasion of the land by the sea that subsequently produced the great calcareous sheet which forms the core and centre of the deposits of the age. Such a record is furnished by the Carboniferous limestone in Ohio and Pennsylvania and by the Cretaceous formation of the far West. It was in the study of the latter that the writer derived his first idea of the explanation now offered of Circles of Deposition, and whatever may be thought of other circles, the history of that one is as clear and unmistakable as any page of print. The proof that the lower Cretaceous sandstone of the far West is an old sea beach, spread by the advance inland of shore waves is capable of demonstration. In my mind every great sandstone formation is of similar origin, and I can conceive of no other power by which these great sheets of mechanical material could have been so widely and uniformly spread.

REMARKS ON PROF. NEWBERRY'S PAPER ON "CIRCLES OF DEPOSITION," ETC. By T. STERRY HUNT, of Boston, Mass.

DR. T. STERRY HUNT, in expressing his great satisfaction at the exposition of Prof. Newberry, observed that beside the mechanical deposits from the retreating and advancing seas, and those of the open ocean, pure limestones, in great part made up of organic remains, must be considered the considerable areas of evaporating sea-basins giving rise to deposits of magnesian limestone with gypsum and salt, often destitute of animal life. In this way the

break between the Medina-Niagara fauna and that of the Lower Helderberg, or what he had spoken of in a recent paper as the third and fourth faunas, was marked. He showed that the Trenton, the Lower Helderberg, the Corniferous, and the Carboniferous limestones, marked four periods of oceanic limestone deposits, and that the gypsum and salt of the Lower Carboniferous indicate a period like the Onondaga between the Niagara (itself magnesian) and the Lower Helderberg. The rocks of the first fauna show a similar series, but in the Ottawa basin we have but an incomplete representation of them. The Calciferous sandrock of that series is however really a magnesian formation with gypsum and brines. He showed that this law of cycles, first pointed out by Amos Eaton, and insisted upon by Hall, had been developed further by the speaker in "The American Journal of Science" for March, 1863 (xxxv, 166), and in an address last year before the American Geographical Society, and published in the "Engineering and Mining Journal" for Jan. 14, 1873, where the dependence of these periods of evaporation upon a climate of great dryness over eastern North America throughout the palæozoic period had been insisted upon.

The connection between evaporating sea-basins and the formation of magnesian limestones was explained by referring to the speaker's researches published in 1859, in which it was shown by him that the formation of the carbonate of magnesia necessary for the production of dolomite and magnesian limestones requires the absence of chlorid of calcium from the waters in which it is deposited, whether this carbonate is generated by the reaction of bi-carbonate of lime on sulphate of magnesia, with the simultaneous production of gypsum, or by the intervention of bi-carbonate of soda. In both cases, as was then shown, isolated and evaporating basins are indispensable conditions of the deposition of the magnesian carbonate (Amer. Jour. Sci., xxviii, 170, 365). The legitimate deductions from this, as to the geographical and climatic conditions of regions during the formation of magnesian limestones, were further insisted upon by the speaker in a paper read before this Association in 1868, and published in the "Amer. Jour. Science" for November of that year, xlvi, 361, on "The Geology of Southwestern Ontario.

It was not, however, the speaker believed, until 1871 that these views found recognition among geologists, when Prof. A. C. Ramsay

by his investigations of the magnesian limestone of the Permian in England was led to reject as untenable the notion held by Sorby (and by others) that this was once an ordinary limestone of organic origin, subsequently converted into dolomite under conditions not yet explained, and to conclude that the carbonates of lime and magnesia of which it is composed had been "deposited simultaneously by the concentration of solutions due to evaporation." To this view Ramsay tells us he was led by physical considerations, and by the depauperated condition of the organic remains contained in these strata, without being, at the time, aware that the speaker had twelve years previously announced the same conclusions with regard to all magnesian limestones, and established them on chemical grounds. [*Quar. Jour. Geol. Soc.*, 1871, p. 249.]

THE AMERICAN MUSEUM OF NATURAL HISTORY IN CENTRAL PARK, NEW YORK; A SKETCH OF ITS HISTORY, INCLUDING A DESCRIPTION OF THE COLLECTIONS PARTICULARLY USEFUL TO AMERICAN NATURALISTS, ITS EXTENT AND PLANS, AND THE CONVENIENCES IT WILL POSSESS FOR THE BENEFIT OF SCIENTIFIC MEN. By ALBERT S. BICKMORE, of New York.

ABSTRACT.

FOR many years a large number of the generous and public-spirited citizens of New York had felt the need of a museum and library of natural history that would be on a scale commensurate with the wealth and importance of our metropolitan city, and would encourage and develop the study of natural history, advance the general knowledge of kindred subjects, and to this end furnish popular amusement and instruction. In 1868 a remarkable opportunity presented itself of securing a rare collection that would form an admirable nucleus for such a comprehensive museum. The most extensive dealer in specimens in the world, Edouard Verreaux, of Paris, suddenly died, leaving in the hands of his widow a collection, which, at the rates he was accustomed

to sell specimens, would have brought over 500,000 francs, $100,-000 in gold. This great collection included the choicest specimens he had been able to obtain from every part of the world, particularly the East Indies and Australia. He had made extended explorations in Africa himself, and had been aided largely in his researches by the French Government. Like most naturalists he found it an easy matter to exchange with his friends and thus enrich his own museum, but to get the requisite funds for carrying on his operations he was obliged to borrow of bankers and mortgage his specimens. Dying suddenly he left the rich gatherings of an industrious lifetime seriously embarrassed with debt. This opportunity it was decided to try to improve, and a subscription of nearly $50,000 was at once made up as a beginning, and since that time about $100,000 has been contributed in money, though the present property of the institution, including the large donations of specimens which have been steadily coming in, could not be replaced, nor could other as interesting and valuable specimens be obtained for less than $250,000. A rare and nearly complete collection of American birds and many fine birds of paradise and pheasants were first purchased of Mr. D. G. Elliot. While negotiations were about to be opened for the Verreaux collections a second museum unexpectedly became available. Prince Maximilian of Neuwied on the Rhine above Bonn (not the Emperor Maximilian of Austria and Mexico) died, and the young son inheriting the estate had no scientific taste and offered the results of his father's life-work for sale. The elder Prince, who formed the collection, passed 1815, 1816 and 1817 exploring Brazil from Rio up to Bahia, and of course a large proportion of the great collections he secured had never at that early date been seen by scientific men in Europe before, and were therefore types of new species.

This collection the American Museum purchased entire. Such typical specimens are the desiderata the museum is specially exerting itself to secure for the benefit of the scientific students in our land. An agreement was soon after made with Mme. Verreaux by which all the choice specimens in her cabinet not contained in the Elliot and Maximilian purchases were selected for the museum, and all these specimens have been safely received from Europe and are now on public exhibition in Central Park. Large donations of shells, corals and minerals have been received, and one

collection of 20,000 insects. The liberal subscriptions first made induced the principal subscribers to act as trustees for the fund and property acquired by it, and by a special act of the Legislature they were created a body corporate—they and their successors to have entire and unrestricted control forever over all the museum property. They have limited their number to twenty-five and the survivors fill every vacancy, thus securing a fixed policy and stable character to the institution. An arrangement has been made between the trustees and the Department of Public Parks in New York by which the city may furnish lands and buildings, while the collections are to be bought and cared for by moneys contributed by the trustees themselves and the generous public. In pursuance of this plan, by which the authorities of the city and private citizens might coöperate toward the common end of establishing a large museum, $500,000 was appropriated by the city to commence a suitable thoroughly fire-proof edifice, and the Department of Parks was authorized to set apart so much of the public lands under their control as they might deem proper and necessary for the proposed structure and its future extensions. In accordance with this law, Manhattan square, situated between Eighth and Ninth avenues and Seventy-seventh and Eighty-first streets, and containing over eighteen acres, has thus been set apart by the Department and accepted by the trustees. Messrs. Vaux and Mould, architects of the Park, have designed a building which may be put up in sections, and thus always be practically complete and yet ultimately occupy the whole area. (Here Professor Bickmore explained a number of large and elegant drawings of the whole plan, which is three times as great as the British Museum, the largest institution of the kind in the world and very properly the pride of every Englishman.) The great object of the museum is twofold. First, to interest and instruct the masses which already throng its halls and occasionally number over 10,000 in a single day; and secondly, and especially to render all the assistance possible to specialists. These wants are shown to be amply met by the large, palatial saloons for the public, and over the whole building a high Mansard story, containing spacious and well-lighted rooms with every modern convenience, where naturalists from every part of our country may pursue their favorite studies for any length of time, and be secure from all possible interruptions. The general arrangement of

cases adopted places them at right angles, and an ingenious device by Mr. Vaux admits light into the part next the wall by a slit through the wall. (This was shown in the drawing.) Contracts have already been matured, which oblige the contractors under the forfeiture of very heavy bonds to complete the walls, floors and roof, all except the interior finishing, by the 1st of November, 1874, and the building will undoubtedly be ready for occupation in the spring of 1875. Professor Bickmore concluded by extending, in the name of the trustees, a most cordial invitation to the members of the Association to visit the museum whenever and as often as convenient, and to avail themselves freely of any aid it may be able to offer them in their scientific labors.

On the Effects of Certain Poisons on Mollusks. By William North Rice, of Middletown, Conn.

The experiments referred to in this paper were made while the writer was employed as one of the assistants on the U. S. Fish Commission, in Portland Harbor, during the past summer. The immediate object was to discover some means of killing gasteropods in a state of expansion, so as to obtain specimens exhibiting them in a somewhat life-like aspect. It was believed that, if such a method could be discovered, it would be of some value for popular and educational museums. The species chiefly experimented upon were Buccinum undatum, Ilyanassa obsoleta, Tritia trivittata, Lunatia heros, Purpura lapillus, and Littorina palliata. The poisons employed were carbonic acid, sulphate of morphia, chloroform, chloral hydrate, sulphocyanide of potassium, cyanide of potassium, hydrocyanic acid, woorara, coniine, quinine, salicine, and santonine. Most of these are well known narcotics, and were, on that account, selected for experiment. Sulphocyanide of potassium has been said to act directly upon the muscular system, destroying the irritability of the muscles. Several of the vegetable alkalies were tried, it being known that some of that class of compounds are more fatal to some of the lower animals

than to man and other mammalia. The smaller species of mollusks were immersed in solutions of the poisons employed. In the case of the larger species, the poisons were generally injected with a hypodermic syringe. Carbonic acid was applied by pouring a bottle of soda water into the vessel containing the specimens. Experiments were also tried of leaving the animals to die in stale water, of putting them into fresh water, and of gradually adding alcohol to the sea water in which they were contained.

As regards the immediate object of the experiments, no very satisfactory result was reached; and a leading design of this communication is to save others from spending time and trouble in fruitless experiments. Perhaps the best results were obtained with hydrocyanic acid, some of the specimens treated with that poison dying in a very satisfactory condition. Some experiments with coniine also succeeded very well. The average results of the experiments with these poisons were not, however, materially better than those obtained by the simpler method of leaving the animals to die in stale water—certainly not enough better to make it worth while to resort to them. Some specimens of Buccinum undatum which died in stale water, remained quite well expanded, though the majority retracted the foot more or less completely within the shell. In the case both of the animals which died in stale water and of those which were poisoned, it was frequently observed that, even when the body in general was considerably contracted, the foot being partly or almost completely retracted, the proboscis or penis or both were quite fully extended. One specimen of Buccinum undatum, poisoned with hydrocyanic acid, not only extended the proboscis, but protruded the lingual ribbon. Fresh water, alcohol (however gradually added to the water in which the specimens were contained), chloroform, chloral hydrate, cyanide of potassium, quinine and santonine, produced complete contraction.

Among the most interesting results of the experiments, was the observation that certain poisons which act with extreme violence upon the mammalia, are very feeble in their action on the mollusca. This is especially true of hydrocyanic acid and woorara. Specimens of Ilyanassa obsoleta, immersed in dilute hydrocyanic acid on Friday, showed somewhat feeble signs of life on the following Tuesday. A specimen of Lunatia heros into which a quantity of woorara had been injected, was found the next day to

show no sign of any injury. Indeed, both of these poisons seemed to produce death very little sooner than the animals would have died in stale water. The sudden introduction of a large amount of carbonic acid in the manner which has been described, seemed to produce no decided effect. On the other hand, chloral hydrate seems to be very suddenly fatal, the animals treated with it becoming instantly contracted, and not resuming their activity when kept for a number of hours in sea water. Cyanide of potassium is similar in its effects, though not quite so instantaneously fatal. The effects of quinine are similar, though less energetic. Chloroform produces instantaneous contraction, and probably death; but, as the animals treated with this poison were not afterwards kept for a time in pure sea water to give them an opportunity to revive, it is not certain that they were really dead.

CALVERT'S SUPPOSED RELICS OF MAN IN THE MIOCENE OF THE DARDANELLES. By GEORGE WASHBURN, of Constantinople.

COMMUNICATED BY C. H. HITCHCOCK.

SIR JOHN LUBBOCK announced not long ago that Mr. Calvert had discovered evidence at the Dardanelles of the existence of man in the Miocene period. He reported that eight hundred feet below the surface there had been found several flint instruments; bones split lengthwise, and especially a fossil bone upon which had been engraved a picture of a horned animal. The author, in company with Mr. Forbes, instructor in mathematics in Robert College, visited the spot last April, and found Mr. Calvert engaged in mining and ready to aid them. The deposits were found midway between the Dardanelles and the plains of Troy. The hills rise abruptly about eight hundred feet above the Straits, and are cut by deep ravines which exhibit the formation.

The lowest formation exposed at this point is a non fossiliferous, argillaceous limestone, nearly white, of irregular thickness, and smooth, like pressed clay, on its upper surface. Above

this are irregular beds of earth and clay of different colors; next is a deposit of white sea-sand five hundred feet thick, which contains, at irregular intervals, pebble beds from one to four feet thick; next is a bed of shell limestone at least one hundred feet thick. These shells are of the brackish water variety. Tchihatheff, in his "Asia Minor" calls this Miocene. The fossils and flints were closely examined, and the investigators arrived at the conclusion that they were shaped by the action of water. Teeth of the mastodon and parts of tusks were found. The bones found were in so small fragments that it was not possible to determine them. Similar fragments of flint, exhibiting no other action than that of water, were found in abundance in a pebble formation near Dardanelles, and it was only a question of selecting from piles of stones those that happened to take a certain shape.

Mr. Calvert has in his collection several bones split lengthwise with the marrow gone. This cannot be denied. But I doubt if such bones prove the existence of human beings. We found in the hole of a jackal, on the plain of Troy, sheep bones which had also been split lengthwise, and inferred that if the bones were split they were the work of beasts. But it is very doubtful if the bones found by Mr. Calvert were broken in this way; for we found that when one of the whole bones was dropped it broke lengthwise, and as all the marrow was gone it resembled the split bones found.

The bone with the supposed engraving is a fragment about eight inches in diameter, shaped like a flattened sphere, one surface smooth, the other rough. It has been called the bone of a mastodon or of a Deinotherium, but is so small that it cannot be determined. Mr. Calvert has had it about twenty years, but only lately, since he read Sir John Lubbock's book on bones in France, has he distinguished the engraving upon it. The smooth surface has some fifty marks, more than half which are grouped in the centre. Taken individually they are peculiar and puzzling, but taken together they can hardly represent a sketch of an animal, or show an evidence of design. We were unable to account in a satisfactory manner for the marks, but suggested they might have been produced by worms when the bone was soft. We found the smooth upper surface of the underlying stratum of limestone was covered with exactly similar marks, many groups of which made more striking pictures than those found on the bone. One specimen is so marked that a vivid imagination can distinguish the picture of

a wild boar with a spear in his side, with the Greek letter π most clearly cut by the side of it. No one would dream of attributing all the marks upon the rocks to design, and I think it equally unreasonable to attribute the similar marks upon the bone to human agency.

The author reports, therefore, in view of the facts mentioned above as to the flints, the split bones and the marks upon the fossil bone, that he believes that Mr. Calvert and Sir John Lubbock (who had never seen the specimens) are mistaken in the conclusions to which they have come; and that they have not been able to find any evidence whatever at the Dardanelles in reference to the antiquity of man.

GEOLOGY OF THE NORTHWEST PART OF MAINE. By C. H. HITCHCOCK and J. H. HUNTINGTON, of Hanover, N. H.

THE country alluded to in this communication is bounded on the east by Moosehead Lake, on the north by the west branch of the Penobscot River, on the west by the water-shed between the Kennebec and Chaudiere rivers, including the neighborhood of Lake Megantic; on the south and southwest by the mountain range of which Mt. Bigelow is the culminating peak. It is partly Palæozoic, with an abundance of fossils, and partly Eozoic. It is of special interest because it is the district where the fossiliferous rocks are limited (in passing towards the White Mountains from the Gulf of St. Lawrence) by the older strata. It has been supposed by many that these Devonian fossiliferous strata passed by gradual metamorphism into crystalline rocks and that the gneisses of New England are to be regarded as altered Palæozoic. The sequel will show that this position is not tenable—so far as can be judged from the rocks of this district.

The fossiliferous rocks of this section were first pointed out by Dr. Jackson, who studied them particularly in the vicinity of Parlin Pond.* He mentions a locality half a mile north of Parlin

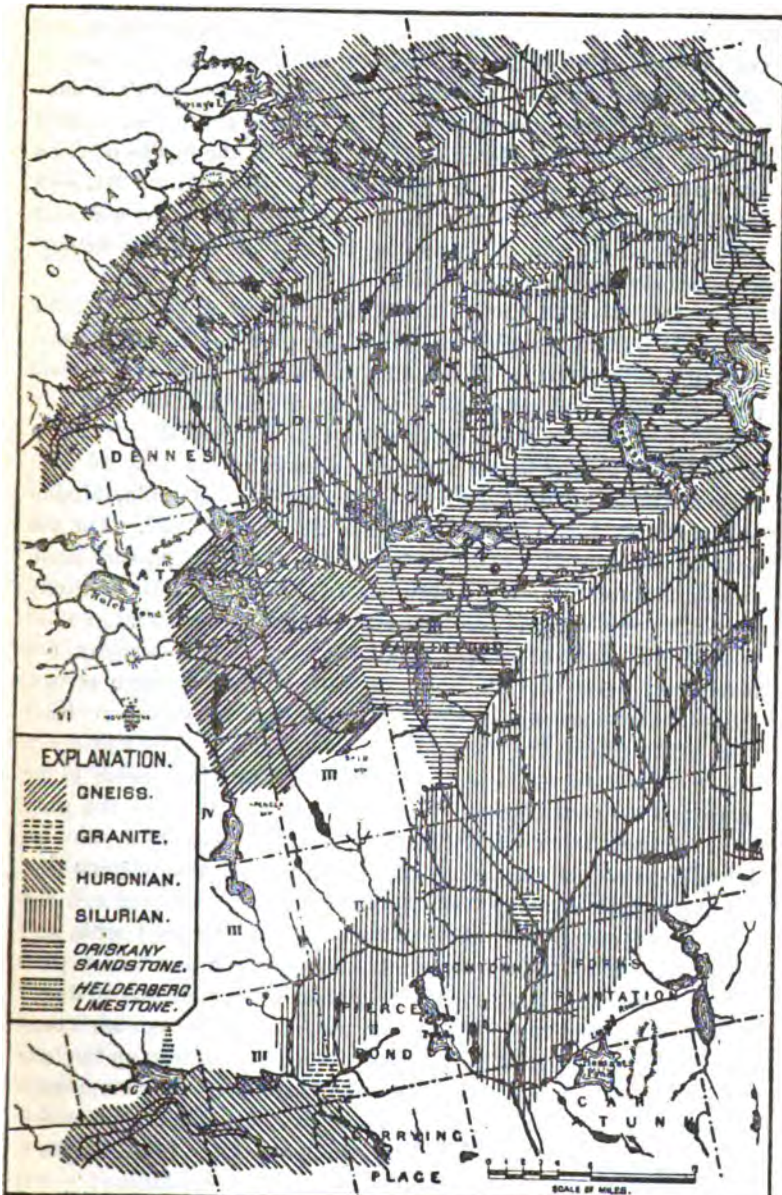
*Third Annual Report, p. 44, 1839.

Pond where he discovered a great number and variety of impressions in a bed of Graywacke. He speaks of them as the most perfect casts of marine fossils that he had ever seen. He seems to have been led to the discovery by the numerous bowlders that have been scattered from this formation as far south as the outer island of Penobscot Bay in the mouth of the Kennebec. Dr. Jackson passed over Moosehead Lake; then he followed Moose River up to the Canada road, which is some thirty miles from the lake; thence he went southward, after he had explored the country northward to the Canada line. In passing up Moose River he crossed the fossiliferous strata diagonally. He noticed obscure fossils in the rocks at Lake Brassua and these are the only fossils he observed on Moose River, or on the lakes that are expansions of this stream.

In 1861-62, one of us when engaged on the geological survey of Maine traversed hastily Moosehead Lake, then westward to the boundary along the west branch of the Penobscot; and the Canada road from the Forks to the Chaudiere.* The upper section showed two Huronian areas overlaid by two bands of clay slates, the latter most likely of Upper Silurian age; the other, the Canada road, exhibited at first strata, most likely Upper Silurian in age (possibly Huronian) overlaid by a band of Oriskany sandstone — to the west of which appeared first granite ledges, then the Upper Silurian strata, followed by the Huronian again extending into Canada.† The numerous fossils obtained at the first visit were named by Billings of Montreal, who recognized in them characteristic species of the Oriskany sandstone. Subsequently, the finding of the Fucoides Cauda-Galli made us believe the representatives of the Cauda-Galli grit appeared on Moosehead Lake.‡

In the hope of gaining some additional knowledge of the rocks of this section, particularly in determining their extreme limit, J. H. Huntington spent a few weeks late last autumn in traversing the country from Moosehead Lake westward. Standing on the summit of Mt. Kineo and looking toward the southwest, we see a high ridge that is almost parallel with Moose River. This ridge is composed of a rock similar to that of Mt. Kineo. It has been described as a bluish hornstone or flint, but it seems rather to be

* Second Annual Report, p. 343, 1863. † *Id.*, p. 283. ‡ *Id.*, p. 331.



GEOLOGICAL MAP OF N.W. PART OF MAINE.

a felsite and although cut by many joints which make the stratification very obscure, yet it appears to have a northwesterly dip. On the west shore of Lake Brassua, probably two miles from the southern extremity of the lake, there is an outcrop of a dark colored shale; and immediately north, there is another outcrop of felsite. If we follow the line of the strike of the felsite of Lake Brassua, four miles S. W. of Parlin Pond, we find Bald Mt. with the ridges running W. and N. E. to be composed of a rock similar to that of Mt. Kineo. So it is possible that the rock may be continuous between these two points.

The shores about the inlet of Lake Brassua are low, and the stream is quite sluggish until after you pass the little Brassua. Perhaps three-fourths of a mile above this lake the stream becomes rapid, and outcrops of rock are frequent. The rock is a ferruginous sandstone cut by numerous joints, and the strata dip S. 20° E. 10°. The fossils are quite numerous and some of them very distinct. The following are the genera: Avicula, Modiolopsis, Orthis, Leptocœlia, Flabellites, Spirifer, Fucoid. For the next three miles the rock is a light brown sandstone, very hard, and in this we did not see any fossils. At the mouth of Stony Brook, a point some two miles from Long Pond, we found another fossiliferous band of rock. There the sandstone is compact, but it frequently contains fragments of slate an inch or more across. Thus it is evident that this rock is newer than the slates on either side. The dip of the rock here is S. 31° E. 2°. The fossils are not so numerous as in some other places, but they seem to be more generally distributed through the rock. This is the only locality where the coral Favosites is found. From this point to Long Pond the outcrop is the same compact brown sandstone that we had seen in several places between the little Brassua and the mouth of Stony Brook. Long Pond is nine miles in length, and is the longest of the numerous sheets of water which are expansions of Moose River. It varies in width from a quarter to a half mile. The first outcrop of rock on the south shore contains concretions of iron pyrites, but no fossils. About half-way up the lake the strata run diagonally across, and there are several outcrops of rock at some distance from the shore. Here there are a few fossils, but as they are on the perpendicular face of the ledges it is impossible to obtain specimens by ordinary appliances; yet it gives us the means of the exact dip of the strata. Six miles from

the outlet on the south shore there is quite an extensive outcrop of rock and an abundance of fossils. The dip of the strata here is S. 20° E. 55°. The sandstone is of a lighter color than that which is generally found farther east, and the strata dip at a greater angle. The fossiliferous portion of the rock is more argillaceous than the non-fossiliferous.

Going south across the strata to Mountain Brook, a stream running east from Owl's Head, there are a few fossils, but rather indistinct. The dip of rock here is S. 40° E. 10°. In the southeast corner of Long Pond township, near Mud Pond, fossils are abundant. The dip is N. 3° W. 6°. The rock generally is of a brownish gray color, and nearly everywhere cut by joints; so that where there are no fossils it is difficult to recognize readily the position of the strata. Taking the fossil locality where the rock begins to dip north as the middle of the axis, we have by trigonometrical calculation the thickness of 2880 ft. for the Oriskany sandstone. The rock northwest of the sandstone is in general an argillaceous schist, and dips toward the sandstone with little or no unconformability. If we follow Moose River above here we shall find a granitic gneiss. The first outcrop is on an island near the outlet of Wood Pond. The fossils from Parlin Pond are *Strophomena magnifica*, *Orthis musculosa*, *Rhynchonella oblata*, *Rensselæria ovoides*, *Leptocœlia flabellites*, *Spirifera arrecta* and *pyxidata*, *Modiolopsis*, *Cyrtodonta*, *Avicula*, *Murchisonia*, *Orthoceras* and *Dalmanites epicrates*.

SECTION FROM LAKE MEGANTIC TO LEXINGTON.

The topography of the country from Lake Megantic to Lexington, though nowhere very remarkable, possesses some points of interest. Historically it is of note as the route pursued by Arnold in his expedition to Quebec in the autumn of 1775. That part of the route from Eustis to Lake Megantic is known only to lumbermen and trappers, and previous to our visit last autumn, the section, except the western border of Lake Megantic, had never been studied with reference to its geology. Lake Megantic is some sixteen miles in length and from two to five and a half in width. With the exception of a settlement at the east end there are only primeval forests with some openings made by the lumbermen and accidental fires. In the vicinity of the lake the hills rise in gentle undulations and are covered for the most part

with a heavy growth of spruce, fir, maple or birch. Southward the hills rise to mountain heights. The mountain ridge forms a water-shed separating the waters of the St. Lawrence from those of the south and forming the boundary between the States and Canada. Two large streams, Victoria on the northwest and Arnold on the southeast, flow into the lake. The outlet, the Chaudiere, is on the northeast, a mile and a half from the northern extremity. On the Arnold River and its tributary, and on the Spider River, the shores are low for several miles. The Spider widens into broad sheets of water, the most prominent of which are Rush and Spider lakes. At the head of Spider River the gap in the water-shed is lower than elsewhere for many miles on either side. Here was a depot of supplies during the boundary survey in 1844–5. The height of the maple and birch trees on land cleared then is from twenty to twenty-five feet. The outlook northward is apparently over an unlimited forest: six or seven miles southward it is obstructed by a range of high hills. Immediately south of the water-shed we come into Maine to the head waters of Dead River. Some four and a half miles from the water-shed are three branches that unite to form this stream. From Rush Lake passing over the boundary into Maine, not more than a mile and a quarter from the height of land, is a sheet of water nearly a mile in length, known as Arnold's Pond; the outlet of which is the middle branch. Along the northeast branch, which rises opposite the mouth of Spider River are several bogs, one of which is a mile and a half in length. Here the stream widens so that boating is practicable to within two and one-half miles of Spider River, where there is sufficient depth of water to float a "birch." These branches of Dead River with their numerous lakes are included in a great basin, and the stream breaks through this basin in its southern border at the chain of lakes, which is an expansion of Dead River some seven or eight miles in length and at its greatest width perhaps a little more than a mile. Half-way down the lakes there is a high mountain ridge, much higher than the mountain sheets between Dead and Spider rivers. Along the south shore the rocks form precipitous heights, but on the north the rise is more gradual, yet there are many jutting cliffs far up the side of the mountain. At the outlet there is a high ridge that extends along the south side of the stream; but on the north the ridge recedes quite a distance from it. From the

chain of lakes the stream, except for a short distance, for sixty miles, is navigable. At the long falls there is a carry of a mile, then dead water for five miles to the great falls, and from this point continuously rapid to the forks of the Kennebec. A large part of Eustis, Flagstaff and Dead river plantation is included in a great basin entirely surrounded by mountains. On the south is Mount Bigelow, a mountain ridge extending ten miles east and west. When it reaches R. 11 it sweeps round to the north through L. 11, the same range. Then the ridge runs west to the long falls on Dead River.

The rocks on a section from Lake Megantic to Lexington are as follows: at the north end of the lake there is a dark gray arenaceous schist that frequently contains iron pyrites. On the west side of the lake and south of Victoria River there is a wrinkled argillaceous schist with a fossil brown slate having small cavities filled with a yellowish brown powder. The dip is S. 45° E. 70°. These rocks are referred to the Upper Silurian by Sir Wm. Logan and they extend down the Chaudiere River to St. Francis. Southwest we have found them in Ditton and on the boundary of New Hampshire. Their eastern limit is near the head of Perry Stream. On their southern extension they pass into mica schist. Following the road parallel with the lake six miles from Lake Megantic, the rock changes and we have green chloritic schists, containing light green epidolitic nodules. The rock here dips N. 35° E. 36°. Farther up the lake we have fine dark gray sandstones. These rocks were examined by Sir Wm. Logan on the lake shore, and by him they were referred to the Quebec group, and were supposed to underlie the wrinkled argillaceous schist just described. This seems quite probable from their relations elsewhere. We have the same succession of rocks in New Hampshire in the vicinity of Connecticut lake, and name the first Coös Group, the second Huronian. Near the boundary of Quebec and Maine and forming the water-shed between Chaudiere and Dead rivers, we have a band of granite, probably eruptive. Following the granite and extending along Dead River for four or five miles we have a granitic gneiss, the strata of which are apparently horizontal. The high mountain ridge at the Chain Lakes is an eruptive granite, and this is followed near the outlet of the lake by a fine grained gneiss that dips 67° and 70° W., and probably extends two miles down the river. We then have for a quarter of a mile a granular talcoid schistose rock that dips 80° N. 20° W. This is followed

by an impure serpentine of a very dark green color, often asbestiform in the joints and appearing to form a synclinal axis. It is followed on the southeast by a granular crystalline rock somewhat coarser than that on the northeast, but otherwise similar. This rock is so cut by joints that it is impossible to determine the dip, though the strike corresponds with the granular crystalline rock northeast of the serpentine.

Leaving the river and following the old road, the next outcrop is a dark green crystalline rock succeeded by quartzite that dips 63° S. 20° E. This is followed by a breccia composed of greenish slate, quartzite and serpentine, and also what appear to be reddish grains of felsite. The breccia seems to be composed of rocks found on either side of it. It is followed on the southeast by a quartzite that dips 75° S. 30° W. At Eustis village, extending a mile northwest and three and a half miles southeast, there is a band of tender fissile slate, generally of a greenish gray color, but having bands of light purple, and southeast of the village are bands of quartzite. This slate forms a distinct synclinal axis. On the Megalloway River we have granular schistose rocks, quartzites, serpentine and slate. The similarity of these to those on Dead River makes it quite probable that the latter are a continuation of the former. Between Eustis village and Mt. Bigelow, there is a greenish chloritic rock that seems to pass into porphyritic gneiss. This rock occupies a large area in Dead River plantation and Flagstaff; since a similar rock was seen in Range 6, Lot 3, and northwest at Attean and Wood ponds, a continuous band may extend thirty miles northward. There is a striking similarity in this rock to one found in Northumberland, N. H., and southward. Here, as at Littleton, N. H., there is a band of Helderberg limestone containing corals that are remarkably distinct. The rock, where the fossils are most abundant, outcrops on an island in Flagstaff Pond. On the west peak of Flagstaff Mountain there is a band of limestone, but the fossils are very obscure. South of the green chloritic gneiss there is a mica schist or imperfect gneiss that resembles very closely the White Mountain series. On the west peak of Mt. Bigelow the dip is 50° N. On the ridge extending from Mt. Bigelow east, where the road passes over it in Range 11, No. 2, the rock is mica schist. It dips 60° N. 5° W., and carries an abundance of small crystals of andalusite. These rocks rest on a porphyritic gneiss that outcrops a few rods south of the height of land. This gneiss resem-

bles the rock of the basin northwest in the valley, and is followed on the south in New Portland by a granitoid gneiss that resembles very closely that associated with the gneiss in the vicinity of the White Mountains.

Adopting the conclusions derived from our study of the rocks in northern New England, we think the porphyritic gneiss south of Mt. Bigelow is the oldest of all the rocks enumerated. The gneisses of Mt. Bigelow and the ridges eastward abound in crystals of andalusite, and appear to belong to the White Mountain series, and to rest upon the porphyritic variety. The series of chloritic and talcoid schists, quartzites and serpentines, appears to be still more recent and to be allied to the Huronian system. The granite and gneiss from the Lake outlet on the east to the Megantic basin on the west may be older than the Huronian upon both flanks.

CONCLUSIONS.

Four important conclusions may be drawn from the distribution of the formations in northwestern Maine.

1. The Oriskany sandstone reposes gently upon Eozoic gneisses — the first bearing scarcely more traces of alteration than the corresponding group in New York, while the second seems to have been metamorphosed and elevated before the Devonian formation was deposited. No further trace of this group has yet been found towards the White Mountains. It has been followed through Maine from one hundred and fifty to two hundred miles, and similar rocks are described in Nova Scotia by Dawson. It can, therefore, no longer be maintained with reason that these strata pass into New Hampshire in a metamorphosed condition.

2. The Oriskany is several times thicker than in its extension in the interior and farther south in Pennsylvania. The greatest thickness mentioned by H. D. Rogers is five hundred and twenty feet, only one-fifth its dimensions in Maine. The greatest observed thickness in New York is only thirty feet.

3. The discovery of new localities of Helderberg limestone indicates a wide-spread submergence of eastern America in Upper Silurian and Middle Devonian times, of nearly fifteen hundred feet. These fossils have been detected at Bernardston, Mass., Lyman and Littleton, N. H., Montreal, Lake Memphremagog and other localities to the northeast in Quebec Province, Eustis, Flagstaff and Spencer Mountain, in the field described above in

Maine, and still greater developments in the northern part of Maine, too extensive to be specially mentioned; hence,

4. There must have been subsequently to the Helderberg, a period of elevation to bring New England to essentially its present position. Possibly this epoch may be indicated in the later elevating force seen upon Mt. Washington. The highly inclined Helderberg strata at Littleton and Owl's Head, P. Q., certainly bear witness to the exertion of a powerful elevating agency.

THE OUTER CEREBRAL FISSURES OF MAMMALIA (ESPECIALLY THE CARNIVORA) AND THE LIMITS OF THEIR HOMOLOGY. By BURT G. WILDER, of Ithaca, N. Y.

NATURALLY, human brains have been most extensively studied, and chiefly those of adults; some have compared fœtal brains with those of *Quadrumana* but the existing doubt and disagreement,* with the lack of any generally recognized basis for the determination of fissural homologies, suggest the need of a different method of study; and as the main object of this and the next paper is to throw doubts upon the value of current opinions respecting brains, it is proper to state the materials upon which my opinions are based. It will be understood therefore that, unless otherwise stated, my present generalizations are based upon these materials only, and are subject to revision when a larger number of specimens is at my disposal.

Where but a single drawing or diagram was made, it generally represents the outer surface of the left side; the second usually the right side, or the upper (dorsal) surface; and the mesial and ventral surfaces were added if their peculiarities required and time permitted. All of these drawings and diagrams were made by myself, and most of them were exhibited at the meeting.

The varieties of dogs' brains will be given in the next paper.

On the following page I give a list of original preparations and drawings of mammalian brains made since July, 1871, and forming the basis of this and the following paper.

* A good example of this is stated by Ecker who includes the anterior central lobe with the frontal, while Gratiolet and Bischoff include it with the parietal.

This note, with some other matter which delay in publication has permitted me to insert, should bear date of December, 1873.

SCIENTIFIC NAME.	POPULAR NAME.	NUMBER OF INDIVIDUALS. FŒTAL.	YOUNG.	ADULT.	TOTAL.	DRAWINGS.	DIAGRAMS.
Homo sapiens	Man	5	....	1	6	8	3
Macacus	White-faced India Monkey	....	....	1	1	....	....
Cynocephalus	Baboon	....	....	1	1	....	2
?	Monkey	....	....	5	5	....	....
Canis familiaris	Domestic Dog	....	6	23	29	58	22
Canis occidentalis	Gray Wolf	3	....	....	3	1	1
Vulpes fulvus	Red Fox	....	....	2	2	2	2
Felis catus, *var.* domesticus	Domestic Cat	5	17	20	42	4	4
Felis leo, *var.* Africanus	African Lion	....	1	....	1	1	....
Felis leo, *var.* Asiaticus	Asiatic Lion	....	1	....	1	5	1
Hyæna vulgaris	Striped Hyæna	....	....	1	1	3	1
Ursus Americanus	Black Bear	....	....	1	1	2	1
Procyon lotor	Raccoon	....	....	3	3	2	2
Putorius Noveboracensis	Weasel	....	....	1	1	1	1
Sus scrofa	Swine	19	4	1	24	....	2
Equus caballus	Horse	1	1	5	7	....	....
Equus	Mule	....	....	1	1	....	....
Bos taurus	Cattle	7	8	5	20	....	1
Ovis aries	Sheep	10	8	....	18	....	2
Capra ægagrus	Goat	....	....	1	1	....	....
Capra ægagrus, *var*	Cashmere Goat	....	....	2	2	....	....
Cariacus Virginianus	Red Deer	2	1	1	4	....	....
Camelus Bactrianus	Two-humped Camel	....	....	1	1	....	....
Mus decumanus	Brown Rat	....	....	2	2	....	....
Mus musculus	Mouse	....	....	2	2	....	....
Arctomys monax	Woodchuck	....	1	1	2	....	....
Fiber zibethicus	Muskrat	....	....	1	1	....	....
Sciurus Hudsonius	Red Squirrel	....	....	1	1	....	....
Cynomys Ludovicianus	Prairie Dog	....	....	1	1	....	....
Hesperomys leucopus	Deer Mouse	....	....	1	1	....	....
Scotophilus fuscus	Brown Bat	....	....	1	1	....	....
Didelphys Virginiana	Opossum	1	....	2	3	....	....
Genera, 28; Sp., 32; Var., 40-45.	Total	53	48	88	189	87	45

These specimens form part of a collection to illustrate the neurology and embryology of domesticated animals, which Professor Agassiz* authorized me to make for, and at the expense of, the Museum of Comparative Zoology in Cambridge.†

It will be seen that the above list of one hundred and eighty-nine individuals includes about twenty-eight genera, represented by about thirty-two species, and about forty-five varieties, the numbers varying according to differing estimate of the taxonomic relations of the individuals.

The size of human brains, the expense of their preservation in numbers, the rarity of apes' brains, and especially of fœtal specimens, together with the complexity of the fissural pattern which man and *Quadrumana* have in common with herbivorous mammals, are additional reasons for selecting other subjects. A simpler fissural pattern exists with the *Carnivora*. Among these the wild *Canidæ* (fox, wolf and fennec) occupy a position midway between the *Viverridæ* and *Mustelidæ* on the one hand, and the domestic dogs, the *Felidæ*, *Ursidæ* and *Hyænidæ*, on the other. That is, all the main fissures found in *Carnivora* are present in the fox, but uncomplicated by contortions and by secondary fissures.

METHOD OF PREPARATION.‡—The present paper treats only of those cerebral fissures which are visible from the outer *side* of a brain properly prepared. Heretofore all brains have been har-

* Since this paper was written, he who inspired it has finished his work in this world. As his student, his assistant and fellow-teacher, I cannot refrain from expressing my sense of bereavement. To me he was not only a great naturalist; he was the wisest of teachers and the kindest of friends; whose criticism was a healthy stimulus and his praise a sweet reward.

† Those who bear in mind that not a single brain was preserved from an entire menagerie which was suffocated in Boston about thirteen years ago, and that no similar collection exists in this country on account of its great cost in time, alcohol and means of displaying, will appreciate the extent of interest which Prof. Agassiz felt in this special undertaking; and while, as Professor in one institution, I must regret that the result of any of my work should leave it for another, yet as it must be years before my own or any other museum can command the means required for such a special collection, I am really grateful for the opportunity of using this material as it came for the instruction of my students, and by this kind of work, avoiding for a season, the outside drudgery in the way of popular writing and lecturing, to which the existing financial condition and policy of the average American University compel its Professors continually to resort, whether ready or not, to the impairment of their powers, and the detriment of the interests of the institution to which they would rather devote all their time, their energies and their enthusiasm.

‡ It may seem that these remarks might be omitted or placed at the end of the paper; but I have become so impressed with the often repeated dictum of Prof. Agassiz that "the method affects the result," that I wish to submit mine at the outset.

dened while resting upon their *base*. They become unnaturally flattened, and are then generally figured from *above* only. Like so many other methods borrowed from anthropotomy, the common manner of extracting the human brain is seldom applicable to those of animals; the skull, as well as the brain, is more useful if vertically bisected, and this seems to be the only way of insuring the safety of the olfactory lobes and the *appendicular lobule* of the cerebellum; the former are rarely figured of their full size (as, for example, in the cat and cheetah. Trans. Zool. Soc., vol. i, pl. xx), while the very existence of the latter seems often unsuspected even in those animals where, by extracting the brain after bisecting the skull, I have found it of great size. In a future communication, I intend to illustrate this peculiar organ and make some remarks upon its connections, mode of formation, function and zoological significance. It is particularly large in the bear but small or wanting in the lion and in cats; being often bulbous at its extremity, the utmost care must be exercised to avoid breaking the pedicel, and I have found it easier to effect the dislodgment by throwing air behind it with a small blow-pipe. Figure 1 represents from below the left appendicular lobule (A L) of a Chinese dog;* it seems to be a protrusion of a portion of one of the horizontal series of convolutions.

I am inclined to think that in most cases, the way to preserve the entire brain in its natural form is to bisect it either before or after extraction, and to place each half upon its *mesial* surface in a flat-bottomed vessel of alcohol. As it rapidly loses weight in alcohol† and gains in water, and as handling out of these fluids is apt to distort it, I would recommend weighing each half of the head before and after extraction; the difference gives the exact weight of the brain; but as the apparatus which I employ (a sort of adjustable "Mitre-box") does not as yet enable me to insure bisection on the middle line exactly, I have not felt justified in comparing the two halves of brains together. If both hemispheres are to be preserved entire, the section should go rather to the left than the right of the middle line, in order to leave the mesial surface of the right hemisphere uninjured; but if the right is to be

* This and the other figures will be found at the end of next paper.

† The extent of this loss may be seen from the following cases; a brain weighing ,065. lost one-sixth of its weight in eighteen hours, and one-third in four days; a brain weighing ,125. lost one twenty-fifth in sixteen hours and one-half its weight in two months; of course the rapidity of the loss will vary with the size of the brain, the amount and strength of the spirit and the frequency of its renewal.

dissected, then the mesial surface of the left should be saved by carrying the section a little to the right; of course, however, if there is certainty of the saw going just between the two, so much the better.

The *pia mater* should be removed *before drawing;* this is best accomplished after the brain has shrunken a little in spirit, using a pair of fine forceps and fine curved scissors.

If possible, both sides of a brain should be drawn; but if only one, the left; and with all *Carnivora* (although not with all *Herbivora*), all the outer fissures may be seen in such a view; while this is not the case in the view from above, even when the brain is flattened. In drawing, each half should rest upon a slip ruled in square centimetres;* if the brain is larger than that of a cat, the slip may be pinned upon a sheet of cork, and two or more threads stretched over the brain, coinciding with the lines hidden by it; then the drawing may be made upon another ruled slip, with great accuracy; the mesial, upper and lower surfaces of the brain may be drawn in like manner, though less easily; and large diagrams may be accurately reproduced, by ruling cloth in squares ten, fifteen or twenty times the diameter of the original drawing; the homologous fissures may be uniformly colored as in the diagrams exhibited; Gratiolet, Owen and Bischoff have colored homologous *folds*, but it is obvious that the same end is more readily attained by coloring the fissures; and that alterations are also more practicable.

It would certainly be an advantage to possess a cast of the cranial cavity for comparison with the brain; and all comparative measurements and weights should take into account the shrinkage of brains, and their loss of weight.†

*I am happy to state that Mr. Geo. Woolworth Colton, the well known map-maker, and a member of this Association, has offered to prepare ruled paper of a size and quality suited to this and other natural history purposes.

It will be noted that the *perspective* is ignored in drawings made by the above method; each fissure is represented as if at a point on a line *perpendicular* to the surface on which the brain rests: a drawing in which this line should be perpendicular to the *convex surface* of the hemisphere would produce the effect seen in fig. 5, plate Ia.

† When a brain is once thoroughly hardened in alcohol it may be kept in weaker spirit or clear water during examination; it rapidly shrinks still more in the air; I am conducting experiments to show how well and how long, hardened brains can be preserved in a mixture of equal parts glycerine and water; which does not evaporate like spirit and, by its greater specific gravity, avoids injurious pressure of the specimens upon each other or upon the vessel; the best way of keeping many brains for study is in a wide tin box two or three inches deep and cased in wood, with a glass cover; if each half of a brain is kept on its mesial surface, no injury can result.

THE CEREBRAL FISSURES.— More attention has been given to the folds (gyri, convolutions, or anfractuosities) than to the fissures (furrows or sulci). But, whatever may be the manner of their formation, the latter really represent the location of the augmented gray, ganglionic or dynamic tissue more than the former; for, as a rule (the only exceptions being the points of oblique junction of two fissures), the contiguous walls of a fissure are nearer together than the two sides of either of the folds which it separates; a line representing the fissure, therefore, indicates the location of a much larger bulk of gray matter than a line of equal width representing any part of the surface of the fold.

Practically too the fissures are by much the easier to describe and designate, and it would be as hard to designate folds without first identifying fissures as to describe the countries of Europe without mentioning its rivers. The sides of a fissure are usually near together and parallel, so that the fissure may be described or figured as a single line of certain direction; but the opposite borders of any one fold are rarely parallel throughout their whole extent.

Moreover, the surface, which in one brain forms two folds, with an intervening fissure, may in another be one continuous fold. What shall it be called? Relatively, at least, the *surface* of a convoluted brain is the same as it was before the fissures appeared; while the fissures are gradually introduced and are to a certain extent capable of identification; and although they may be wholly due to a vertical elevation of the contiguous folds, yet it is the fissures and not the folds which can be said to increase, to connect, or to remain separate. Granting, then, that folds are the ultimate object of our study, fissures are first to be so thoroughly identified in all animals that when one of them or one of the folds is mentioned, there can be no doubt of its being recognized by all.

Fissures may be studied in four ways:

First: As to their general nature.

Second: Singly, as to their special peculiarities.

Third: As evidences of zoological affinities.

Fourth: As indications of intellectual power.

The last view will be considered in the next paper. According to the first view, we may at once separate three of Owen's fissures from the rest. The *rhinal* is the line of separation between the olfactory crus or tract and the cerebrum proper. The *median* or

inter-hemispheral fissure divides the two cerebral hemispheres; and although in most *Carnivora* the true fissures seem to be arranged with some reference to it, and although it has clearly defined borders, yet neither of these features exists with *Herbivora*. The sylvian fissure marks the location of a kind of mound of cerebral substance, the "Island of Reil," and its manner of formation is somewhat peculiar, as shown hereafter.

FORMATION OF FISSURES.—No one doubts that all brains, even the most deeply furrowed, were smooth at an earlier stage of development. This transformation, so far as the result is concerned, might be compared with the segmentation of an undivided yolk; but probably the process is more often comparable with the formation of the primitive furrow; and although they look like clefts or depressions in the brain mass, it is probable that the fissures are the result of a difference in the rapidity of growth of different parts; certain points or lines remaining relatively stationary, and becoming the bottoms of depressions or fissures. Still I cannot rid myself wholly of the idea that shallow fissures, at least, may be formed by direct *depression;* and if Ecker is rightly translated he seems to have this view respecting all of them; "Actual convolutions are formed in these districts only with the further progress of the formation of fissures (p. 14). The formation of the convolutions is, of course, entirely dependent on the development of the fissures; and in the region of the temporal lobe, in which the latter are most variable, the convolutions are so too" (p. 65).

But on page fifteen, in contrasting the sylvian with other fissures he says that the latter "originate simply from *depressions or folds* of the cerebral cortex." (The italics are mine).

Now, as regards the aspect of the cerebral surface in the adult, it makes perhaps no great difference whether we speak of the fissures as depressions or the folds as elevations; and the former is more natural on account of the greater extent of the elevated surfaces; so too in conversation it is easier to say that the sun rises and sets than that the earth revolves upon its orbit; but in scientific language it would seem proper to speak according to the fact rather than the appearance.

Undoubtedly one source of confusion is the indiscriminate use of terms signifying the transformations themselves and the condi-

tions reached thereby; and we might avoid it by discriminating between appearance and aspect, formation and conformation, development and presence or existence, etc.

As a single example of the looseness of our present expressions, on account of lack of definite information, Huxley (Comp. Anat. of Vertebrates, p. 492) enumerates among the distinctive features of the human brain, "the filling up of the *occipito temporal* fissure," as compared with that of apes; in its *most literal* sense this would imply that something *filled* a previously existing fissure; a little less literally, that the bottom of the fissure grew up to the surface of the adjoining folds, so that a fœtal fissure did not exist in the adult; and still again, and this would be a perfectly legitimate interpretation, it might indicate the fact, that a fissure which exists in apes did not exist in man in any stage; but even this would be capable of at least two meanings, according as the readers believed, or not, in actual evolution.

The formation of fissures seems to proceed very rapidly.* I have traced it in kittens of the same litter, killed at short intervals beginning at birth; and even allowing for individual and sexual differences, it would appear that during the first week, a change may occur perceptible within six hours; the most favorable fissure for this purpose is the *frontal*.

The large superficial cerebral vessels often lie in the fissures; but that this is merely a coincidence, and not a cause, is indicated by the frequent departure of these blood-pipes from their trenches; the slight furrow which marks the course of a large vessel across a fold has generally a more regular form with better defined borders. Where the folds are much contorted as in man and most herbivora, as compared with their simplicity at an earlier stage, one can hardly avoid the conjecture that the folds are formed under pressure, and that the brain behaves much as would a piece of thick cloth crowded into a cavity. Still more suggestive of this idea is the lateral contortion of the median lobe of the cerebellum in cats; in the newly born kitten (Fig. 2, K), this is vertical in direction and presents few folds; in all but one of the adult cats that I have examined, the median lobe appears, as in Fig. 2, C, laterally contorted; the progress of these remarkable changes will be fully illustrated on another occasion.†

* As does the yolk segmentation with Turtles (Agassiz, Cont. Nat. Hist. U.S. 2, 523).

† Ecker speaks (p. 10) of the "formation of convolutions as a necessary consequence of certain mechanical processes of the brain and skull," but it is not clear how much influence is attributed to the latter by this expression.

Yet while we may recognize a sort of *correlation* between the existence of fissures and the need of enclosing a certain amount of gray matter within a space which is represented by the cranial cavity, it by no means follows that osseous walls are the immediate and direct cause of the convolution; much less does it follow that the particular direction of the fissures is occasioned by the ridges upon the inner cranial surface with which they coincide. In short, we may regard the size of skull and of brain as concomitants of the degree and character of fissuration without attempting, as yet, to assign to them the relation of cause and effect. It may not be proper to compare cerebral fissuration with the primitive formation of the encephalic lobes, but it is certain that this latter takes place independently of cranial circumscription, especially in many fishes where the cranial cavity far exceeds the brain mass; and it would be interesting to ascertain whether this interspace exists in any of those fishes which, like *Elacate*, present some cerebral fissuration. At present the matter must be regarded as undecided; and the way to elucidate our own lack of information is to ask ourselves whether, in total absence of cranial walls, any cerebral convolution would be developed in the higher *Mammalia*.

FISSURAL HOMOLOGIES.—In order to describe the variations of fissures in different brains, they must first be identified. Although Owen has (Comp. Anat. of Vertebrates, vol. iii, pp. 114 to 143) undertaken to homologize the fissures of the higher mammalia (*Gyrencephala*) throughout, and has rarely admitted the liability of error (as on p. 117), yet the very completeness of his determinations throws doubt upon them in view of the lack of reference to individual peculiarities, and the renunciation of development as a guide to homology; and it will be safer to keep in view the conclusion of Gratiolet. (Mem. sur les plis cerebraux de l'homme, p. 10.)

"It is sufficient to compare the brain of an ape with that of a carnivore or ruminant in order to show that in the different mammalian orders, the cerebral folds present very different arrangements.

These differences are such that it would be imprudent to establish parallel divisions and to search for homologies. In fact that search has no certain basis, and we do not hope to accomplish it in a moment."

CRITERIA OF HOMOLOGY.—Having no true structural features, they present, as tests of homology: 1. Position in relation to

internal structure (as the *rhinal* and *sylvian*). 2. Position in relation to other fissures so determined. In connection with this latter test, we must ascertain whether anything like *transposition* is possible; this question will be raised in respect to special fissures. Their connections, branches, length, and general direction are probably of less value. Great aid is always to be had by comparison with simpler brains of allied species, or with the brains of young of the same species. The extent of variation in length, direction and connections, which may exist without invalidating their homology, is most readily seen by comparing the corresponding fissures upon the two halves of one brain (plate 3, figs. 12, 13); it appears that a long fissure may be represented by several short and disconnected ones; that branches may or may not exist at either end (these branches are almost invariably dichotomous); that two fissures wholly separate in the fœtus, and in other species may unite either directly or by a branch. Good examples of this are the *lateral* and *coronal* fissures, which are perfectly distinct in the fœtus in some adults, and on one side only of others, but which show a tendency to unite; a marked constancy in the location and direction of a branch may, as in this case, indicate the point of union. Finally, with respect to several fissures, we must either deny a homology which would be otherwise unquestioned, or admit that in one species or on one side, its manner of formation may greatly differ. This will be exemplified in connection with the special fissures in this and the following paper; for example the *presylvian*, and the *ectosylvian*. While insisting, however, upon the provisional nature of many of the names which authors have given to the cerebral fissures of mammals, it is necessary to adopt some nomenclature in order to be understood, and in the present paper the names given by Owen will be employed with some modifications.

SPECIAL FISSURES. THE SYLVIAN.—This is the most constant of all fissures; there is no question respecting its existence or its name in all brains which are fissured at all.*

Its length, direction, branches and connections vary consider-

*On this account I have not hesitated to mark this fissure upon all the figures, *s*; but since there is some doubt respecting the name or the nature of all other fissures, the letters designating them are placed outside of the figure, in order to allow revision; most of the figures are shown white on a dark ground; this will allow future alteration in the relative width of fissures in order to indicate their depth or relative constancy.

ably, but, as a rule, in the adult it forms a nearly straight fissure directed dorsad and backward, never reaching the dorsal margin of the hemisphere, and rarely if ever inclining forward, though generally nearly vertical in *Herbivora*. Its manner of formation is very peculiar, and may be readily traced in new born or fœtal kittens and puppies; in these and also in the fœtal wolf (fig. 6), there appears, where in the adult the sylvian is to join the *rhinal*, a rounded elevation (which is probably homologous with the *Insula* or Island of Reil, of anthropotomy) bounded above and behind by a shallow trench; in front this island is apparently continuous with a narrow area of cerebral substance which still more anteriorly broadens into that part which lies just behind the olfactory lobe; the primitive *sylvian* fissure is therefore an ∞-shaped depressed line whose posterior end joins the rhinal, and whose anterior end is turned upward; by the gradual projection of the cerebral mass above this line, it overhangs the depressed tract, so that the ventral part of the curve reaches the *rhinal* fissure and coincides with it for a certain distance; this portion I have ventured to call the *basisylvian* (Bs); by the growth of the mass before and behind the semicircular area now left, and the final approximation of the walls, the Insula is at length wholly concealed, and the semicircular trench becomes a single fissure; strictly speaking therefore, the sylvian is an arched fissure like those which surround it (*ectosylvian*, *supersylvian* and *lateral*).*

PRESYLVIAN (Ps.).—The anterior and ascending (dorsad) extremity of the *primitive sylvian* seems to correspond with the "ascending

*From a translation (Cerebral Convolutions of Man) which has just come into my hands, I find that Ecker of Freiburg, four years ago, observed the formation of the *sylvian* fissure, and that some of his conclusions upon this and other points are nearly like my own. I am sure that Ecker will be only glad that another has reached similar results from different materials, for he employed human brains exclusively, while I have purposely discarded them for the simpler brains of *Carnivora*. Certainly he and all other honorable scientific men would accept the collections and drawings made by me as evidence of my entire independence in the work; but for the satisfaction of others, including the writer of an editorial in "The New York Evening Post" for Aug. 30, which directly charges me with unacknowledged borrowing from Ecker, I am compelled to state that to-day, Sept. 8, 1873, for the first time, have I learned the contents of Ecker's work.

Moreover, while not questioning the correctness of Ecker's statement that in man "the whole hemisphere curves itself in an arch, concave below, around the place of entrance of the cerebral peduncle" (p. 15), it is proper to say that the brains of kittens and puppies examined by me do not confirm it; nor is it easy to see how so long a fissure as that of the bear could be formed in that way; it is evident that for the elucidation of this and many other points, we need a very extended series of observations upon the developing brain of many animals.

branch" (Ecker, fig. 1, S″) in its manner of formation, and in its relation to the *sylvian;* but the intervening space in all brains I have examined is so much larger than the "operculum" of anthropotomy that I hesitate to affirm it before observing its formation in many intermediate species. Moreover, in a lion (fig. 18), there is a small fissure between the *sylvian* and what I take to be the *presylvian*, which in some respects more nearly resembles the "ascending branch" in man; while in a bear (fig. 10) and raccoon (fig. 11) there is a similar one in front of the *presylvian*, which may be only a continuation of the slight upward curve at this point which the *rhinal* presents in many dogs. I would suggest the name *presylvian*, at least for the fissure already described in *Carnivora.* It is evidently the same which Flower refers to as *superorbital* (Anat. of *Proteles;* Proc. Zool. Soc., 1869, p. 479), but there seem good reasons for regarding it as ideally, at least, a dismemberment of the *sylvian.* I say *ideally*, for although generally so in *fact*, yet occasionally there is no connection whatever, and that which would in respect to position be called *presylvian* is an isolated fissure. This is the case on both sides of a raccoon (fig. 11),* and on the left of an impure tan terrier dog; of the right of this brain I have no drawing, but think the union is as usual. This is certainly a point which should be clearly understood before we can be sure of the value of our determination; at present I am not prepared to explain it. It will be noted also that in most dogs and in the lion, the *presylvian* is not only very long, but apparently double, as if a special and independent fissure had become connected with its dorsal end; whether this is the case can probably be decided by sections, for there is reason to think that an independent fissure is always deepest at its middle where it may generally be supposed to commence; and if the fissure in question is shallower at the point of suspected junction we may fairly conclude that it is really a compound fissure.

FRONTAL† (F.). This fissure is very characteristic of *Carnivora*, being absent, so far as I know, only in *Paradoxurus* figured by Gervais. (Nouv. Arch. du Museum, tome vi, pl. 9, fig. 2.)

* But in another specimen the connection seems to exist as usual.

† I have adopted Owen's name as applied originally to the brain of *cat* and *cheetah;* but am not sure that it is homologous with that so called by him in the human brain. Flower has called it *crucial.* P. Z. S., p. 479.

The *frontal* appears from without as a cleft in the mesial margin; in kittens it begins as a mere shallow depression which rapidly deepens and narrows; it is nearly as much a mesial as an outer fissure, and in some cases joins one of the mesial fissures so as to appear a continuation of it; as seen from above the frontal extends outward and sometimes forward (as in fox). As a whole I have seen it take a backward course, only in a black bear, both sides, and a skye terrier, right side, although when curved, its outer end may turn slightly backward. It rarely branches, or if so but very slightly as on the right of a St. Bernard (524); in some cases, as in right of bull terrier (514); an apparent bifurcation is merely the union with it of a small secondary fissure. But even such junction is very rare; on right of bear (502, fig. 10), it joins another at right angles, but on left a considerable space intervenes.

SUPERSYLVIAN (Ss.). Next in independence, in constancy, and in order of formation seems to come that semicircular fissure which Owen calls *supersylvian;* perhaps it should precede the frontal in the above respects, but like so many other points, my present material does not enable me to determine this. I am quite certain, however, that Owen's table (C. A. V., iii, p. 136) does not in all respects (as its author admits) represent the relative rank of all the cerebral fissures. It generally divides the surface of the hemisphere into two subequal portions; its usual relation to the other fissures is seen in the fox (fig. 3) and the fœtal wolf (fig. 6). In this, it forms a nearly regular curve with no branches or connections; and whichever we may conclude to be its representative, in the young terrier (fig. 7) it would appear to begin as a longitudinal groove about midway of its final extent and nearly over the *sylvian*. This is also the case in cats; but in most brains its hinder end either branches or joins some small fissure, while, as a rule, its anterior end bifurcates, the longer arm reaching forward and ventral often with a slight dorsal turn at the extremity, while the shorter points obliquely forward and dorsal and often enters the lateral fissure just outside (as in hyæna, fig. 9). This little branch so closely resembles the one which is given off at the junction of the lateral and coronal in nearly all cases as to suggest that it is, like it, due to a union of two independent fissures; but of this there is no evidence. The fact that a similar branch some-

times leaves the *ectosylvian*, as in fox (figs. 3 and 4), suggests a like constitution for this latter fissure, or else a serial arrangement of cerebral foldings which is not as yet accounted for upon any theory of correlation between mind and brain.

In a lion (fig. 18) the Ss is irregular, with branches and junctions with other fissures. In a bear (fig. 10) and raccoon (fig. 11) we have a peculiar arrangement, the explanation of which I forbear to suggest until I see fœtal brains of these species. The weasel presents only two fissures where most *Carnivora* have three, and it is not easy to say which they are; a similar doubt is admitted by Owen (C. A. V., iii, p. 117) in comparing the brain of *Coati* (*Nasua*) with that of the stoat; and I ask no better evidence of the fact that our knowledge of the zoological value of fissures is as yet incomplete than the comparison between my figure of the weasel's brain (fig. 8) and Owen's figure of the stoat's; for the animals are similar species of closely allied genera, if not, indeed, members of the same genus (Allen, Bull. Mus. Comp. Zool., No. 8, p. 167), or varieties of the same species (Gray, Proc. Zool. Soc., 1865); yet my figure shows two fissures outside of the *sylvian*, while Owen's has but one which he calls *supersylvian*.

LATERAL (L.). This is usually a curved furrow which divides the space between the *mesial* border and the *supersylvian* into two nearly equal parts.* The name was given by Owen, probably in reference to its approximate parallelism with the mesial border, which is often quite striking, as in the lion and hyæna; but its anterior extremity is inclined to connect with another fissure, the *coronal*, so constantly and so smoothly that but for occasional exceptions and observations of fœtal brains, one would incline to regard the whole as a single fissure with a branch, mesiad, resembling that of the *supersylvian;* but a careful comparison indicates that the *lateral* generally bifurcates anteriorly, and that the ventral arm is joined by the *coronal;* occasionally they miss connection, as on left side of terrier (fig. 12), shepherd (512), and of another small dog (540), on right of pointer-shepherd (fig. 14), and on both sides of skye terrier (503) and young tan terrier (534), on

*This division of the cerebral surface into subequal areas by the fissures will be mentioned in the next paper; of course, as the hemisphere is convex, no figure can represent the true relative distances of the fissures unless the surface is projected upon a plane (as is done with a fox's brain, fig. 5); it would appear, however, upon a series of transverse sections, which I hope to show upon another occasion.

left side of lion, and in cats generally; the weasel has no *coronal;* the bear and raccoon are peculiar in this as in other respects. In the young terrier (fig. 7) the *lateral* is very short and the union has not taken place. The *Coronal* (C) may be passed over with what has been said in connection with the lateral. But there are two secondary fissures which are associated with the hinder end of the *lateral;* one of them, which generally occurs in cats, has been called *medilateral* by Owen; it lies *mesiad* of and usually behind the *lateral* and often joins it, but seems to be an independent fissure. When there is any fissure mesiad of the *lateral* in dogs, it lies farther forward, and is generally interrupted, so that I am not certain of the homology; but in some cats (fig. 15) the true *medilateral* seems to coexist with an anterior fissure mesiad of the *lateral;* while in some dogs, greyhound (fig. 16), the *lateral* is prolonged backward, *as if* by a *medilateral*, while a separate fissure, apparently a true Ml, lies between it and the mesial border, and another, El, lies outside between it and the *supersylvian*. This last, which has not so far as I know received a name, may be called the *ectolateral*. Flower evidently alludes to its constancy in *Canidæ* (P. Z. S., p. 482), as occasioning the bifurcation of the posterior limb of the third gyrus (the value of his generalization will be discussed farther on).

ECTOSYLVIAN (Es.). This fissure is in some respects the most peculiar of all, for it presents differences not only of adult condition, but also of manner of formation, which lead us to doubt the value of this character. Its simplest, and what may be regarded as its normal, aspect is presented in the young terrier and fœtal wolf, and in the adult fox, where it forms a curved line of greater or less extent between the *sylvian* and the *supersylvian* (it is probably wanting in the weasel, fig. 8); this regular form occurs also in some dogs, as a setter (10) (left side), and St. Bernard (524) (right), where, however, there are two or more small offshoots from the convexity, like the single and apparently normal anterior one of the fox; but while the above instances would suggest that the ectosylvian is a simple arched fissure commencing at a point just above the tip of the sylvian, and increasing at both ends, many others would incline us to describe it as composed of three independent pieces, one in front, and one behind the sylvian, and the third connecting those above it; as, for example, in the terrier (fig. 25).

And that this is a not impossible view of its formation is shown by the fact that in several dogs, as right terrier (511) (fig. 13), and left greyhound (fig. 16) and St. Bernard, this top piece is apparently wanting altogether, leaving the front and hind posts of the door unconnected. This is apparently the normal condition of things in all *Felidæ* (fig. 17), although the ends may branch, and, even as in lion, join other fissures. In many dogs, as the Pomeranian (fig. 20), the posterior upright may be in great part wanting, or abbreviated and joined with the *sylvian;* finally, in *Hyæna* (fig. 9), the anterior upright *seems* to be transferred *behind* the *sylvian;* but this involves a very grave general question of homology which there is no means of solving at present.

It will be understood that the foregoing are by no means offered as full accounts of the outer fissures, even with respect to my present materials; but rather as hints for monographic work upon them when a larger number of specimens or accurate drawings shall be available. Let me suggest in this connection, however, that to be useful, the *original drawings should be made by the anatomist*, and that the transfers should be made under his eye; an abbreviation or extension of a fissure, which would appear trifling to the most conscientious artist, might involve a contradiction of important generalizations respecting its connections.

But before any final work can be done in respect to fissures, we need a *complete account* of the brain of some one mammal, giving its appearance from all sides, sections and dissections of all parts, and demonstrations of the relations which may exist between the fissural pattern and the internal structure; then a full series of figures representing all the stages of development, both of the brain as a whole and of its parts; on some accounts the fox would be the most useful species, but as it is not to be had in large numbers, and as dogs are ineligible as a standard, from the breed differences as well as from the usual complexity of the fissural pattern, we shall probably find the cat most available for this purpose; such a work would form a fitting continuation of Straus-Durckheim's magnificent monograph of the Osteology and Myology of that animal.*

TAXONOMIC VALUE OF THE FISSURAL PATTERN. Upon this point Gratiolet speaks as follows (*op. cit.* p. iii) :—

*It is one of the tasks which I wish to accomplish, but trust this will not deter others from undertaking it.

"In like manner there is a particular type of cerebral folding in the makis, the bears, the cats, the dogs, etc.; in short, in all the families of mammalia (d'animaux). Each of these has its own character, its norm, and in each of these groups the species can be easily combined according to the sole consideration of cerebral folds."

Gervais* concludes that we may recognize order, family, genus and even species by the brain (Nouvelles Archives du Museum, 7, vi, p. 152).

Flower says (*op. cit.* p. 480): "For working out all the modifications of the brain convolutions of the *Carnivora*, a larger number of specimens would be required than are at present accessible; but the series in the museum of the College of Surgeons is sufficiently extensive to show that they will furnish important indications of affinity, and that these indications correspond remarkably with the evidence afforded by the cranium, digestive and reproductive organs."

While admitting the *probability* that such a family norm of fissuration does exist and may hereafter be designated, yet the careful study of an amount of material greater in some respects, at least, than previous writers seem to have had, only makes me urge the importance of Gratiolet's remark, that "the value of any conclusions respecting ideal unities has a necessary condition, that of resting upon a sufficient number of exact observations" (*op. cit.*, p. iii). The need of this may be seen by an examination of Flower's generalization, respecting the very groups which we can best illustrate (*op. cit.* p. 482).

"The dogs (*Cynoidea* = *Canidæ*) are very uniform in their cerebral characters having always four distinct and regular gyri surrounding the fissure of Sylvius, which is short and approaching a vertical direction. The first and second arched gyri have the anterior and posterior limbs equal, the third has the posterior limb broad and bifurcated."†

"All the other *Carnivora* have only three arched gyri on the outer surface, the first or lower one of the dogs being either wanting or concealed beneath the second within the fissure of sylvians. In the hyæna its hinder limb is partly exposed."

"In the *Arctoidæ* (=*Ursidæ*, *Procyonidæ*, *Mustelidæ*, *Ailuridæ*,

*But although this author figures the brains of eighteen species of Carnivora (and casts of the cranial cavities of these and other species) he seems to ignore the existence of individual differences, and gives but a single brain for each species and none whatever from dogs (excepting casts).

†By what I have called the *ectosylvian* fissure.

Lutra and *Enhydra*), the fissure of Sylvius is rather long and slopes backwards; the inferior gyrus has the limbs long, corresponding with the length of the sylvian fissure; the anterior rather narrower than the posterior (especially with the true bears); the middle gyrus is moderate and equal-limbed; the upper one large, very broad in front and distinctly marked off from the second posteriorly, as far as near the lower border of the temporal lobe; except in the smaller members of the genus *Mustela* where the sulcus separating the superior from the middle gyrus is less produced posteriorly than in others of the group. In *Galictis vittata*, however, the brain is quite a miniature of that of a bear; but the middle convolution is united with the upper one at its superior anterior angle."

"In the *Æluroidea* (including all other Carnivora excepting the *Pinnepedia*), the sylvian fissure is moderate and nearer to the vertical than in the last group. The gyrus which immediately surrounds it is wide, especially the posterior limb which is generally twice the width of the anterior and is divided by a vertical fissure,* well marked in the cats and hyænas. In the cats the anterior limb is also partially divided. In the civet both limbs are simple, the second gyrus is moderate and simple. The superior gyrus is wide in front but small posteriorly, the sulcus which separates it from the second not extending quite to the hinder apex of the hemisphere (the suricate agrees with the hyænas rather than with the civets in the general character of its brain convolutions)."

Of the *Arctoidea*, Prof. Flower may have had more material than I, but in the absence of exact enumeration, his characterization of the fissural pattern seems to me insufficient at least; if by dogs, Prof. Flower includes only the feral *Canidæ*, his generalization may be not far from correct; although the backward slant of the *sylvian*, in both my own and Gervais' drawings, is generally greater than in hyæna and weasel, and equal to that of cat and lion. But if the domestic dogs are included the definition would not apply to many of them; for the bifurcation of the third gyrus is often so complete as to constitute two equal gyri, as on left of terrier (fig. 12), and the outer or fourth gyrus may be likewise bifurcated, as in left of greyhound (fig. 16), while the first and second gyri are, as a rule, rendered irregular by the peculiarities of the ectosylvian; moreover, the generalization respecting all other

* Which I believe to be the hinder upright of the *ectosylvian*.

Carnivora involves a denial of the homology of the complete *ectosylvian* of the fox with the incomplete one of the cat, yet this last is very nearly like those on the left of the terrier (fig. 12) and greyhound (fig. 16).*

Other discrepancies might be pointed out, if it were possible to present, in this paper, figures of all the brains which I have prepared; but so long as Prof. Flower makes no reference to the differences of individuals of the same species, to variations of age and sex, or to differences between the right and left sides of the same brain, I shall be obliged to doubt the value of the generalizations.

LATERAL VARIATION. I wish it had been possible to offer here drawings of both sides of all the brains of the feral, as well as domestic *Carnivora*. I do not recall a case in which this lateral variation has amounted to the total absence of a main fissure upon one side; it consists rather in a difference of length, depth, branches and connection, or of nearness to other fissures; the minor fissures, however, present very great lateral variations as to presence and location. Since most of the examples given are from domesticated dogs, I do not wish to lay too much stress upon the fact of lateral variation, but in no work have I seen both sides of an animal's brain figured or described; and since no two brains of different species can be so nearly related as the two halves of the same brain, it is evident that a careful study of lateral variation will furnish a test of the value of the differences observed among brains (see plate 8).

LATERAL COMPENSATION. Lateral variation is often *compensatory*. For instance, a long fissure of one side may be represented by several short ones upon the other, the aggregate length being equal to the single one; a straight fissure may represent a curved one; or a single one may have as counterpart a shorter one with a branch; in one case, the total length of a bifurcated sylvian fissure is just that of the longer but undivided fissure of the opposite side.

*The foregoing certainly raises the question whether we can rightly look for taxonomic assistance among the organs of domesticated animals: but meantime it seems proper to include our canine varieties in any generalization respecting the group of *Cynoidea*.

The functional significance of this will be alluded to in the next paper.

CONCLUSION. The foregoing is far from a satisfactory view of the subject; but it is all I can offer at present. My chief object has been to point out the defects of our methods of preparing and drawing brains, and the insufficiency of material for making any generalization respecting that mammalian order whose brains are most readily obtained and whose fissural pattern is comparatively simple. With a single specimen or figure of the brain of *Felis*, *Canis*, *Hyæna*, *Ursus*, *Mustela*, one might make generalizations as to specific, generic and family fissural patterns which would be quite as true to nature as many which are annually published upon this or other departments of Comparative Anatomy, but they might be controverted by other specimens or even by the other halves of the same. The greater complexity, both from secondary fissures and from contortions of the primary fissures, which prevails with the brains of most *Herbivora*, is an *a fortiori* argument against making the attempt to determine their fissural patterns before the *Carnivora* are disposed of. After a pretty careful study of the specimens and works at my command, I feel justified in asserting that we cannot as yet characterize the fissural pattern of any mammalian order, family, genus or even species without the risk that the next specimen will invalidate our conclusion; that our studies in this direction should be based upon the careful comparison of accurate drawings of a much larger number of specimens than now exist in any museum; that nearly allied forms of *Carnivora* should be compared; and that the most satisfactory results are obtainable from large series of fœtal and young brains of the same species, and, if possible, family and sex, in order to eliminate minor differences.

ADDENDUM ON THE LION'S BRAIN. The kindness of Mr. Lee Powell* has just enabled me to prepare the brain of a young African lion, seven and one-half months old; the left hemisphere is here figured (fig. 19) for comparison with the Asiatic. The most striking difference is in the great development of the temporal lobe (the postsylvian region), which not only projects laterally more than in the other, but also *forward* over the region

*Of Robinson's Circus and Menagerie, Utica, N. Y.

just in front, so as partly to cover it and make the ventral portion of the *sylvian* coincide with the ventral branch of the *ectosylvian*, (Es); the frontal region is less prominent, and the outline of the cerebellum is quite different. In the Asiatic lion the left *coronal* is wholly independent; likewise the right *coronal* of the African; but the right of the former joins the *lateral*, which is the usual arrangement, while the left of the latter joins the *supersylvian* in a similar fashion. Other differences might be pointed out both between the two brains and the two halves of each; but it seems to me that these alone are enough to make us hesitate from basing a *diagram* of the fissural pattern of this species upon any such number of specimens as are likely to be found in any museum; while the same peculiarities present almost insuperable obstacles to a recognition of particular folds as organs of special mental faculties separated by certain fissures.

[The figures illustrating this paper are given in the plates, between pages 248 and 249, and their explanation will be found on page 249.]

CEREBRAL VARIATION IN DOMESTIC DOGS, AND ITS BEARING UPON SCIENTIFIC PHRENOLOGY. By BURT G. WILDER, of Ithaca, N. Y.

THE following observations are based upon the careful study of thirty-two dogs' brains, representing fifteen to twenty breeds. There were four of the same family, a mother and three children of different ages; two others nearly related to them, and two pair of brothers of different ages; the others are not known to be related; most of them are supposed to be of pure breeds.*

*The figures referred to in this paper are included with those of the preceding paper in the plates placed between pages 248 and 249.

LIST OF DOGS' BRAINS PREPARED AND DRAWN BY ME, AND FORMING THE MATERIAL UPON WHICH THIS PAPER IS BASED.

M.C.Z.* No.	Breed.	Age.	Sex	Weight of Body, in grams.‡	Weight of Brain.	Ratio, in thousandths.	Fig.
1	Pomeranian or Spitz.	adult.	♀	8,837.	,068	.007	20
3	" } children of No. 1, by the same father, but of 2 separate litters.	5 weeks.	♀	1,316.	,047	.035	21
2	"	4½ "	♀	1,006.	,041	.040	22
4	"	54 hrs.	♂	,132.	,008	.060	23
215	" } later children of mother of father above mentioned.	3 days.	♀	,213.	,010	.047	24
216	"	3 days.	♀	,247.	,011	.044	25
	Eng. rat terrier (small blk. and tan).	at birth.	♀	,092.	,005	.054	
522	Eng. rat terrier brother of above.	24 hours.	♂	,081.	,008	.099	
	Spaniel ½ pure.	at birth.	♀	,221	,007	.030	
511	Eng. blk. and tan terrier (small).	6 mos.	♀	1,320.	,038	.028	12,13
512	Shepherd.	young.	♂	1,952.	,055	.028	
540	Shep. cur (pt. terrier?)	6 weeks.	♀	2,228.	,058	.021	
541	Mexican (Chihuahua).	17 years 8 mos.	♂	2,436.	,050	.020	
6	Eng. terrier } brothers.	9 mos.	♂	5,300.	,074	.014	
7	"	3½ yrs.	♂	5,300.	,069	.013	25
526	Italian greyhound.	1 yr.	♂	6,074.	,067	.011	
8	Ital. greyh'nd impure.	adult.	♂	4,367.	,065	.010	
520	Spaniel (large impure).	adult.	♂	6,158.	,062	.010	
536	Chinese (hairless).	9 mos.	♂	7,026.	,074	.010	1
503	Skye terrier.	15 yrs.	♂	7,800.	,072	.009	
578	Hound.	20 yrs.	♂	22,450.	,108	.005	
9	Setter (large).	12 yrs.	♂	25,400.	,106	.004	
	Newfoundland.	adult.	♂	38,345.	,120	.003	26
13	Bull and cur.	12 yrs.	♂†	40,570.	,125	.003	
	St. Bernard.	old.	♀	40,820.	,098	.002	
25	With seven others the record of which is more or less imperfect.						

No. 7 was not weighed; he was slighter in form than No. 6, but the weights are assumed to be equal; the "fresh weight" of the brain is computed by forming a proportion with another brain

* This is the number on the Catalogue of preparations of Domesticated Animals in the Museum Comp. Zool.

† Castrated at about six years old.

‡ For uniformity, a *full stop* is placed after the number of grams (the unit of weight), and a *comma* after the number of kilograms (1000 grams).

of nearly equal weight when hardened, but the fresh weight of which was also known: as to the weight being greater than that of the older brother's brain, I can only adduce the greater mental and physical activity which it displayed.

The brains of dogs are by no means common in museums, and figures of them are even more rare, partly, perhaps because the very commonness of the species induces delay in its examination,* but partly, I am inclined to think, from a notion that since they are all called dogs, there can be no great anatomical differences between them. Yet aside from any question of their origin from different specific forms of feral *Canidæ*, the fact is patent that our various breeds of dogs differ among themselves in respect to size, color, form and habit far more than would be required for the discrimination of species among wild animals; and there have not been, so far as I am aware, any investigations to show whether, or not, these external distinctions coexist with structural peculiarities.

It had long been my wish to undertake such an inquiry; and the liberality of Prof. Agassiz, in authorizing me to make for the Museum of Comp. Zoology a collection to illustrate the neurology and embryology of domesticated animals, has afforded me the means of commencing the investigation.

The table of absolute weights of brain and its ratio in thousandths to the whole body is mainly confirmatory of the general rule that young mammals have proportionally larger brains, and that the smaller species and varieties in like manner excel the larger; but the difference between, for instance, a little tan terrier and a Newfoundland is something prodigious, as seen by the following selected table, where the large dogs are represented by the Newfoundland, the medium sized by the English terrier (common size) and the small and young dogs by the small terrier and youngest Pomeranian.

No.	Variety.	Age.	Body.	Brain.	Ratio.
4	Pomeranian.	54 hrs.	,132.	,008.	.060
8	Eng. terrier (small).	6 mos.	1,320.	,038.	.028
7	" " (large).	8¼ yrs.	5,300.	,069.	.013
	Newfoundland.	adult.	38,345.	,120.	.003

*As the house fly and mosquito are seldom among the first captures of the entomologist.

Generalizations like the above, and others which might be made respecting the ratios at different ages, in the two sexes and in various breeds, are evidently provisional until we have a much larger mass of material.

I would add that measurements were taken of the intestines; the capacity of the stomach and coecum was recorded and all viscera were weighed, so that I shall at some future day be able to present some statistics respecting them, and also respecting the degree of variation in the form of the stomach and coecum, of which many specimens are preserved, inflated, either at Ithaca or in Cambridge. This is the case also with all the other mammals here mentioned.

TABLE SHOWING THE RATIO OF BRAIN AND BODY WEIGHTS OF A FEW MAMMALS, CHIEFLY CARNIVORA.

M.C.Z.	Scientific name.	Common name.	Age.	Sex.	Weight of body.	Brain	Ratio.	Jaw-flexors.
577	Macacus?	White faced.	5 yrs.	♂	2,939.	,082.5	.028	
	Vulpes fulvus.	Red fox.	adult.	♀	2,918.	,047.	.016	.078
580	Canis lupus.	Gray wolf.	4 days *a. p.*		,460.	,009.	.019	
	Canis familiaris.	See special table.						
	Felis catus dom.	See special table.	average of 6 adults.		2,847.	,027.	.009	
552	Felis leo.	African lion.	7½ mos.	♂	11,230.	,162.	.014	.117
12	Hyæna vulgaris.	Striped hyæna.	old.	♀	33,770.	,110.	.003	.800
502	Ursus Americanus.	Black bear.	1 yr.	♀		,240.		.550
577	Procyon lotor.	Raccoon.	adult.	♂	5,540.	,044.	.008	.040
528	Putorius Noveboracensis.	Weasel.	nearly grown.		,100.	,005.	.050	
188	Equus caballus.	Mare.	14 yrs.	♀		,684.		
379	" "	"	adult.	♀		,597.		
175	" "	Horse.	adult.	♂		,580.		
347	" "	Colt.	at term.	♂		,361.		
354	" "	"	?		15,938.	,190.	.012	
385	Bos taurus.	Durham bull.	2 yrs.	♂	560,000.	,337.	.0006	
587	Camelus bactrianus.	Camel.	?	♀	299,813.	,615.	.0025	1.247

In comparing the weight of the brain with that of the flexors of the lower jaw (*temporals* and *masseters*) we find, for instance, that

the jaw muscles are about eight times heavier in a hyæna, four times in a Newfoundland, twice in a bear, a fox, and camel, but the same weight in a tan terrier, while in the young lion (552) they are only about two-thirds the weight of the brain, although this ratio must alter greatly as the animal grows older.

TABLE OF TWENTY-THREE DOMESTIC CATS.

M.C.Z.	Variety.	Age.	Sex.	Body.	Brain.	Ratio.
220	Common ? } same litter.	17 days.	♂	,180.	,013.	.073
219	" } same litter.	"	♂	,262.	,013.	.049
218	" } same litter.	"	♀	,250.	,013.	.052
222	"	5 days.	?	,128.	,018.	.063
40	"	8 days.	?	,080.	,004.	.050
38	"	at birth.	♀	,110.	,003.5	.050
39	" (sister of 37).	36 hrs.	♀	,075.	,003.5	.047
37	"	12 hrs.	♂	,092.	,003.5	.038
542	Maltese.	?	♂	,560.	,022.	.037
48	"	23 days.	♂	,359.	,014.	.039
25	" (in part).	?	♀	,648.	,021.5	.033
24	" " "	2 mos.	♀	,800.	,025.	.031
34	Common.	3 days.	♀	,099.	,003.	.030
510	Maltese (in part).	?	♀	,963.	,023.	.034
26	"	?	♀	1,770.	,026.	.015
32	Common.	adult.	♀	1,882.	,025.	.013
	"	"	♂	2,591.	,031.	.012
20	" (striped gray).	young.	♀	1,912.	,023.	.012
30	Common.	?	♀	2,276.	,027.	.012
23	"	adult.	♀	2,370.	,028.	.012
28	"	"	♀	2,978.	,027.	.009
22	Maltese (in part).	"	♂	4,550.	,031.	.007
21	" " "	"	♂	2,712.	,025.	.007

The following inferences may be drawn, provisionally, from the foregoing table.

1. The ratio of brain to body, in the adult cat, is about the same as in the adult dogs of the medium sized breeds: namely, .007 to .015.

2. In kittens of the same litter (as 218, 219, 220 and 37, 39) the brain weights are more uniform than the body weights, and the latter causes a variation in the ratio.

3. Although the increase of the *body weight* is much more rapid than that of brain weight, when the whole period of growth is considered, yet a comparison of 38, 39, 37, 34 with 218, 219, 220, 222, 48, shows that the brain must grow very rapidly during the first two or three weeks after birth concomitantly with the increase in bodily powers and the use of the senses.

A comparison of 2 and 4, among dogs, looks the same way; and in both cats and dogs, it will be remembered that the formation of fissures proceeds very rapidly during the earlier days. With pigs, calves and colts, on the other hand, I have found the fissures already deep and numerous long before birth, and it will be interesting to contrast the relative increase of brain and body weights in the *Carnivora* and *Primates* which are born helpless, and the *Herbivora*, which are in fuller possession of their faculties at birth.

General Form.—Some dogs' brains are high and rounded, while others are low, long and narrow in front; of the latter type are those of setters, Newfoundlands (Fig. 26), St. Bernards, shepherds and bull dogs; in all of these the olfactory lobes are visible for about half their extent when the brain is seen from above but they are wholly concealed by the hemispheres in the Pomeranians (Fig. 20), greyhound (Fig. 16) and terriers (black and tan, Fig 12), the Chinese and Chihauhau dogs; and between the two groups come the bull terrier and skye terrier.

In the fox and wolf the brain is narrow and low in front, but in the lion it is rather high; while in the domestic cat, though low, the frontal region is very broad; evidently, however, it is not easy to discriminate between the effect of large size of a certain region and the relatively small size of an adjoining one, and it must be remembered that in all very young dogs' brains the olfactory lobes are hidden, but this is probably from their own undeveloped condition.

The greater prolongation of the olfactory lobes and of the adjoining region of the cerebrum, in front of the *presylvian*, which generally prevails in the larger dogs at least, as compared with the *Felidæ*, might be held to indicate their superior power of scent; but this proves nothing respecting any *mental faculty.*

M.C.Z.	Animals.	Fig.	Length of Hemisphere in millimeters.*	In front of frontal.	Ratio.
13	Bull and Cur.		.069,	.023,	.333
7	Tan terrier.	25	.053,	.010,	.188
14	Pointer and shepherd.	14	.045,	.013,	.288
	Cat.	17	.032,	.003,	.094
510	Lion.	18	.071,	.013,	.183

The above table is in no way intended as an index of the zoological or psychological relations of the several animals, but as a single proof of the impossibility of basing generalizations respecting groups upon one or even several individuals; for in respect to an element of brain form which might naturally be noted in any attempt at characterization, there is nearly as much difference between two dog varieties as between two Feline species, or between the cat and the terrier.

Fissural Complexity.—There must be, of course, a limit to the depth of fissures (or to the elevation of folds), although we have, as yet, no means of ascertaining the nature of the limitation, nor whether it is uniform in all brains; but supposing it to be equal in two given cases, it is evident that a larger number, or length, whether of branches or secondary fissures, indicates a correspondingly larger amount of gray matter; and this, supposing its *quality* to be equal in the two cases, indicates a greater amount of brain power.

1. Now the cerebral mass is capable of expending nerve force in three directions, which are ideally distinct, at least in their purpose, but practically linked together in most cases.

1. Physical, } for the individual.
2. Mental, }
3. Sexual, for the species.

At present we have no way of ascertaining from the brain alone, whether its peculiarities relate to greater mental, physical, or sexual power.

We would naturally account for the more numerous fissures of dogs, as compared with the feral *Canidæ*, upon the ground of

*A *full stop* is placed after the place for the number of *meters* (the unit of measure), and a *comma* after the millimeters (thousandths of a meter.)

their higher mental capacity; and upon this ground must be explained the somewhat remarkable fact that the brain of an adult Pomeranian female (Fig. 20) has fewer fissures than that of her five weeks old pup (Fig. 21); for the father was a trained dog, while the mother was comparatively unintelligent.

But the wolf, according to Gervais' figure, has more secondary fissures than the fox, and this must be accounted for by its greater *physical* power.

Perhaps this is also the explanation of the great fissural complexity of the young lion, as compared with the adult cats or even most dogs; but Professor Agassiz has suggested to me that the greater power indicated by the condition of the lion's cerebrum may be connected with its prodigious *virility*, the complete sexual act having been performed nine times in an hour, under his observation, and the same rate having been maintained during at least two successive nights.

In a young lion's brain (Fig. 19) the depth of the *supersylvian* fissure is at least one-half the thickness of the hemisphere at that point and in its plane; while in an adult cat's brain the depth was only one-fourth, and in a dog's about one-third; all the other fissures were very deep in the lion, and the layer of gray matter very thick.

I hope to make a careful measurement of several dog's brains, according to the method adopted by Wagner, with such suggestive results.

2. There are *individual variations* among the adults which do not affect the presence or relative position of main fissures, but their length, direction, branches, connections and continuity, and, by inference, the manner of their formation; these variations enable us to recognize any brain and may in some cases approximate them to other carnivorous families.*

3. The two sides of the same brain present just such variations as those above described between different individuals.

The few instances cited show to what extent this variation may exist; so great is it, indeed, that I do not think it possible to "mate" two hemispheres by their fissural pattern alone, without taking into account the similarity of size, or general form.

* The resemblance of the *ectosylvian* fissure of certain dogs to that of the cats is referred to in the preceding paper.

The number of specimens is not yet large enough to justify any inference respecting the sexual peculiarities of brains.

4. There are resemblances between brains of the same breed, which lead us to suspect the existence of a uniform modification of the general pattern for different breeds.

This is noticeable in the Pomeranian series; but in the first place some other brains show the same tendency of the *ectosylvian* to join the *sylvian*, and in the second place the near relationship of all the younger dogs to the single adult prevents our knowing how far the resemblance is one of *family* and how far of *breed*, in general.

The same doubt exists respecting two tan terrier brothers (6 and 7) whose brains are similar, especially since they do not particularly resemble those of others of the same breed.

5. All of these dogs' brains are comparable in respect to the fissural pattern, both among themselves and with the feral *Canidæ*.

There is *something* which leads even the child to call all dogs by that name, whether they be terriers or St. Bernards, greyhounds or bull-dogs, poodles or mastiffs; just what this feature is, has not, so far as I am aware, been scientifically described; nor have I any suggestion to make; the case seems to be similar with their brains; I do not think I should mistake the brain of a dog for that of any other animal, but I cannot yet say upon what grounds, and am by no means sure that my diagnosis would be correct in all cases.

But it is evident that in order to ascertain whether or not there is any peculiar dog pattern, and if so, what it is, a much greater amount of material is required than is now accessible.

If nothing else, I have at least shown that no fissural pattern involving several fissures can be correctly known from the examination of a single brain, much less one side of such brain. The collection at Cambridge is very large as compared with that of most museums, but far too small for any final conclusions. I merely venture to express the hope that when we are able to compare say twenty-five brains of the same breed of dog, we may be reasonably sure what are its cerebral characteristics, and probably several hundred specimens will be required to demonstrate the essential features of the dog's fissural pattern as contradistinguished from all other *Canidæ*.

The immense cost of such a collection raises the question of the value of the result, and this is only part of a general question not sufficiently considered when scientific inquiries are begun.

If a thing is to be done at all, it can be accomplished far more completely and economically by one person or one institution than by several working separately or at different periods. I would therefore ask members of the Association to bear me in mind when they have or know of a dog of pure blood and well known character, which has outlived its usefulness; a careful transportation and death by chloroform will obviate distress on the part of both the animal and its master.

THE RELATION OF THESE VARIATIONS TO SCIENTIFIC PHRENOLOGY.*—In using the phrase "scientific phrenology" I place myself between two fires; for the professional phrenologist claims that all phrenology is scientific, while many scientists deny the compatibility of the terms. Let it be understood then, that I use phrenology in a general sense, and to avoid coining a new word, to indicate the study of the brain as an organ of the mind; and, further, that I am not in the least biased by the views of others, but am trying to learn the truth by a new method of investigation. In justice to myself also, it is right to state that I speak as an anatomist and not as a physiologist, much less as a psychologist. With all due respect for the latter classes of investigators, I believe that they have been hitherto building upon very slight foundations, and that an immense deal of hard work in the way of anatomical comparison must be done before they can be sure of the grounds upon which their experiments and conclusions can be based. Further, I hold that most of the facts already at hand are not of the right sort; and that we have begun at the wrong end and in the wrong way in our efforts to correlate brain and mind.

MENTAL ASSOCIATIONS OF PARTS OF THE BRAIN MASS.—Four methods may be employed in order to ascertain the mental associations of parts of the brain mass:

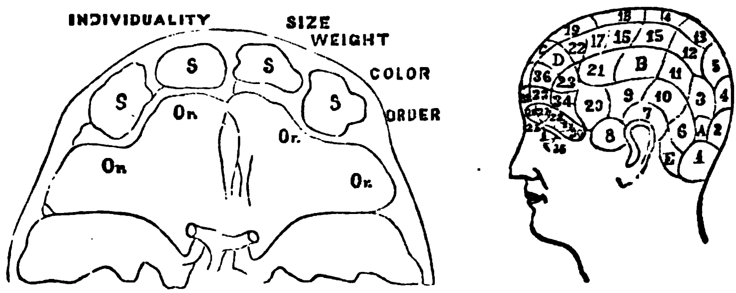
1. The Phrenological. The skull was accepted as an index of the form of the brain, and a certain number of cases of correspondence between cranial forms and marked characters was held to demonstrate the locality of mental faculties and propensities.

*This phrase is used by Gervais (Nouvelles Archives du Museum, tome vi, Pl. 9, Fig. 2). This author gives admirable lithographs of many brains and moulds of the cranial cavity, and suggests the value of a comparison of carnivorous brains, for the advancement of "scientific phrenology."

That this method is not satisfactory appears from the following considerations.

a. No definite and constant correspondence whatever exists between folds and fissures of the brain and the outer cranial surface.

b. Several important faculties are located over the frontal air sinuses, as pointed out by Dr. Cleland, from whom the accompanying figure (Fig. 27) is copied.*



c. No phrenologist has ventured to draw the accepted map of mental faculties upon the surface of the brain itself; and, from what we have learned, it is certain that what would fit one side would not fit the other.

d. No allowance is made for the extensive sheet of gray matter which covers the mesial surfaces of the hemispheres, and which, so far as has been shown, differs in no way from the rest.

e. To all appearance, the gray matter forms a continuous sheet, which may be more or less folded in the adult but was perfectly even at an earlier stage.†

f. By the failure (in several cases, though one is enough) on the part of the most expert phrenologist to determine correctly the character of an individual by examination of the head.‡

2. The Pathological. By comparing cerebral lesions with mental manifestations observed during the life of the individual. This is at present unsatisfactory, because :

*The lingering admirers of Phrenology. Popular Science Review.

† This is perhaps not so conclusive an objection as might at first appear; for the present non-recognition of lines of demarcation is no proof of their non-existence; and the experiments of terrier and others seem to demonstrate something like a localization of power in respect to *muscular action*; this, however, would not seem to require the same circumscription of area as in the case of distinct mental faculties.

‡ My views in respect to phrenology are given in "The Tribune Extra," No. 3. and my personal experience in "The Ithaca (N. Y.) Democrat" for Jan. 29, 1873. They will shortly appear in a republication of the lecture above referred to in the "Half-Hour" series of Messrs. Estes and Lauriat.

a. It has failed of absolute demonstration in respect to an apparently single organ, the cerebellum. for Dr. Hammond accepts neither the view of Flourens that it coördinates muscular action, nor that of Spurzheim that it is connected with sexual feeling, and concludes that it has no special function.*

b. The large number of cases in which aphasia coexisted with lesions of a tolerably definite region of the left hemisphere has not yet convinced the highest authorities that the mental faculty of language is there situated.

c. There is reason to suppose that peculiar mental conditions may exist when no cerebral lesion is recognizable, and that lesions may exist without mental disturbance.

d. Finally, Brown-Sequard concludes "from the study of every symptom of brain disease, that all parts of the brain may, under irritation, act on any of its other parts, modifying their activity, so as to destroy or diminish, or to increase and morbidly to alter it."†

3. The Experimental. This has been introduced by Fritsch and Hitzig, Beaunis and Nothnagel,‡ who, by galvanic or chemical irritation or destruction of certain cerebral regions of dogs, have demonstrated the existence therein of centres of action for different sets of muscles. This method promises great results, but, it may involve injury and abnormal action, and thus far has

* Quart. Journ. of Psychological Medicine, April, 1869.

† On the mechanism of production of symptoms of diseases of the brain, Archives of Scientific and Practical Medicine, vol. i, p. 117.

In this connection the following conclusions of Brown-Sequard (which I have but lately seen in the original, Feb., 1874) are of great significance: "An immense variety of symptoms in different individuals may be caused by a lesion in one and the same part of the brain; and the same symptoms may result from the most various lesions." Archives of Scientific and Practical Medicine. March, 1873, p. 259.

The above, together with the decided disbelief in the correctness of the generally accepted views of nervous physiology, which are elsewhere in the same journal expressed by the same high authority, should lead us to be cautious in our deductions from any single series of observations.

‡ Fritsch and Hitzig.—Ueber die electrische Erregbarkeit des Grosshirns. Archiv für Anatomie, Physiologie und wissenschaftliche Medicin, 1870, p. 300.

Hitzig.—Ueber die beim Galvanisiren des Kopfes entstehenden Störungen der Muskelinnervation. Archiv für Anat. Physiol. und wissenschaftliche Medicin, 1871, p. 716.

Weitere Untersuchungen zur Physiologie des Gehirns. Do., 1871, p. 771.

Beaunis.—Note sur l'application des injections interstitielles à l'étude des fonctions des centres nerveux. Gazette Médicale de Paris, 1873, Nos. 30–31.

Nothnagel.—Interstitielle Injectionen in die Hirnsubstanz. Centralblatt für die med. Wissenschaften, 1872, page 705.

Experimentelle Untersuchungen über die Functionem des Gehirns. Virchow's Archiv, 1873, p. 184.

The above references are taken from Prof. H. P. Bowditch's excellent report on Physiology, Boston Med. and Surg. Journal, July 17, 1873, p. 79.

shown only a connection between cerebral substance and *muscular organs*, not of brain and mind.

The above method has been later employed by Ferrier,* who, however, used faradic instead of galvanic electricity.

Dr. Ferrier's results are interesting in the highest degree, and it is only to be regretted that he has not at once published a diagram of a brain, so that all may know to what parts he refers in his description.

It is worthy of note that in the following expression he jumps at no conclusions respecting the localization of *mental faculties*.

"There is reason to believe that, when different parts of the brain are stimulated, ideas are excited, but it is difficult to say what the ideas are. There is, no doubt, a close relation between certain muscular movements and certain ideas."

But the results of such experiments can hardly be accepted as indicative of the localization of mental faculties in the human brain, or that of any animal than the one experimented upon, until it is shown that homologous folds exist in both; and even then the fact that the same faculty, for instance, *combativeness*, is manifested by a dog with its jaws, by a horse with his hind legs, by a bull with his horns, and by human beings, with hand or foot, or only with tongue, renders the practical *phrenological* application a very difficult one. The following suggestion was made by me a year ago (lecture on the brain above referred to).

"To apply galvanic stimulus to the supposed organs of prominent and distinct faculties, either indirectly, through the skull, or directly, in cases of accident; perhaps it is not too much to suggest that the *experimentum crucis* could be tried, if an enthusiastic believer would allow himself to be trephined, through a few protuberances. We could then witness the manifestation of friendship or combativeness, as the subject clasped the operator in his arms or planted a blow between his eyes.

It cannot be denied that trephining is one of the perilous operations, but a healthy man would have a fair chance; a criminal would do well to accept the risk in case of possible slow strangulation, and should he die during the operation, it would merely anticipate by a score of years the method of execution, namely,

* FERRIER.—"Experimental Researches in Cerebral Physiology and Pathology." British Medical Journal, April 26, 1872. Also: "A new method with the brain;" read before British Association for Advancement of Science, 1873, and printed in "Nature," and in "Popular Science Monthly" for Dec., 1873.

by an overdose of chloroform, to which I believe we shall be compelled to resort, in the interests of decency, humanity, and even artistic effect."

But while convinced that this method of investigation will throw great light upon the question of the correlation of brain and mind, I am by no means confident that it will demonstrate the localization of mental faculties in certain cerebral folds. On the contrary, although satisfied that my present material is too small for final conclusion, I am more and more inclined to think that a cerebral hemisphere acts as a unit, either singly or with its fellow; that, other things being equal, a greater number and depth of fissures indicate a greater mental or bodily power, and that the actual number of the fissures has only a *general functional significance, analogous to coils of intestine, or corrugations of mucous membranes;* but that like these, or like the peculiar turns of horns and the arrangement of turbinated bones, their arrangement in what is called the fissural pattern may be fairly accepted as indications of *zoölogical relationship*, more and less remote. The extent of their value in this regard must be ascertained by much more extensive comparison than has been made.

4. Cyno-phrenology. The method here advocated is, in theory, that of the phrenologists, but its practice differs therefrom in two important respects: *a.* In employing the brain itself for comparison, in using large numbers, in comparing the two sides, and in keeping the brains for such study as is impossible from figures. *b.* In employing not human, but canine brains, upon the grounds of their simpler fissural pattern, their smaller size, and consequent easier preservation in large number, and the possibility of an accurate acquaintance with the mental characteristics of the dogs. At present we are well acquainted with the natures of our family, our friends, and of public men; their brains are rarely at our disposal for scientific investigation; so we study the brains of paupers and uncultivated persons whose characters are known to us either not at all or very imperfectly. With dogs, the brain and the mind of the same individual are at our disposal; while lateral, epochal, individual and sexual variations, together with those appertaining to families and breeds, may be more easily observed and separated.

I have records of the habits and disposition and mental attainments of several dogs, but the material is far too slight for

anything like a scientific deduction. I even hesitate to associate the great width of the supersylvian fold of a bulldog, with his fighting powers, for his *disposition* was gentle enough.

EVEN DISTRIBUTION OF FISSURES.—I cannot help thinking that at least one of the elements of the fissural pattern is the subdivision of the surface into approximately equal areas. This is best demonstrated by projecting the surface of a hemisphere upon a plane. But the only brain on which I have as yet done this is less satisfactory than I expected; and I shall hope hereafter to offer sections of the hemispheres which will better indicate both the distance between the fissures and their depth.

If particular folds are the organs of either mental faculties or distinct groups of muscles, and if as such organs they are circumscribed by the intervening fissures, then how can we explain the following facts?

1. That these folds are generally continuous around the ends of the intervening main fissures.

2. That even where "islands" are formed by the extension of branches or by secondary fissures, there was a time when these surfaces were continuous upon the same level.

3. That no one has yet demonstrated any structural lines of demarcation corresponding to the fissures.

4. That there may be differences between the two halves of the same brain equal to or even greater than those which distinguish individuals or even species.

The zoologist and comparative anatomist would not hesitate to call attention to the greater or less width of a certain fold, and would regard it as of possible taxonomic value; but the cautious physiologist would certainly shrink from the inference that this was conclusive proof of the greater or less power of certain muscles or mental faculties; and he would be yet more loath to infer that the apparent obliteration in many dogs of the posterior leg of the front or lowest fold (which in fox intervenes between the *sylvian* and *ectosylvian*) indicated the absence of either the muscles or the faculties which the fox exercises through it; or even to infer that the apparent transfer of the anterior leg of this fold in hyæna, to behind the *sylvian* fissure indicated a real transfer of a mental or muscular "organ;" although, should the fissural arrangement prove constant, it would be unhesitatingly accepted as of great taxonomic value.

Plate 1. Formation and Nomenclature of Fissures in Carnivora.

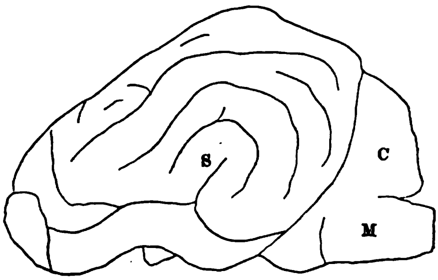


Fig. 3. Fox, *V. fulvus.* ♂ adult.

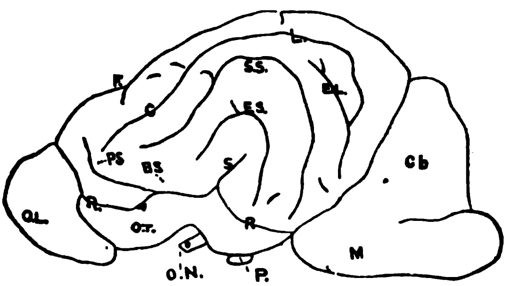


Fig. 4. Fox, *V. fulvus.* ♀ (513.)

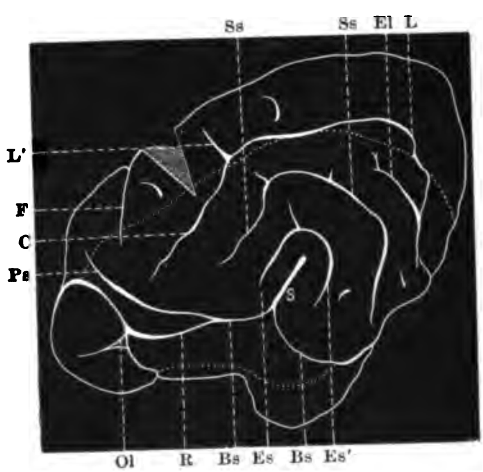


Fig. 5. Fox. Same as 4, projected on a plane. (See page 218, note.)

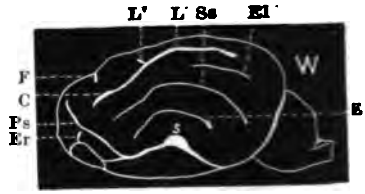


Fig. 6. Fœtal Wolf (*Canis occidentalis*): four days before birth. (530.)

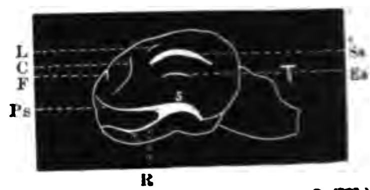


Fig. 7. English Terrier: one day. ♀ (533.)

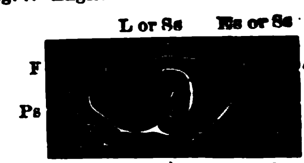


Fig. 8. Weasel. *Putorius Noveboracensis.* Nearly grown. (528.)

Fig. 1. Appendicular lobule of Cerebellum, left side, of Chinese dog. (p. 217.)

Fig. 2. Median lobe of Cerebellum of Kitten (K) and Cat (C), showing contortion during growth. (page 221.)

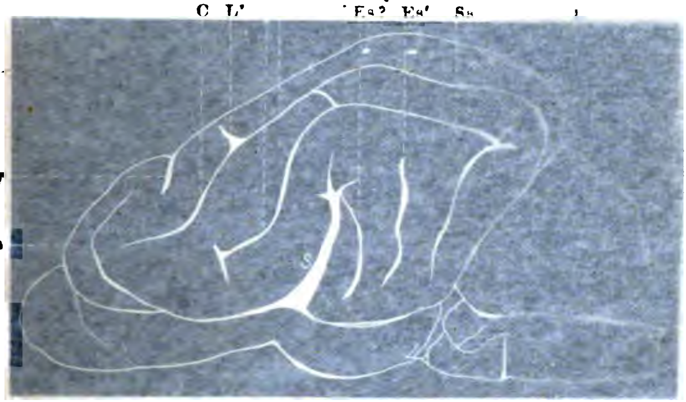


Fig. 9. *Hyæna vulgaris*, ♀ old. (12.) (p. 229.)

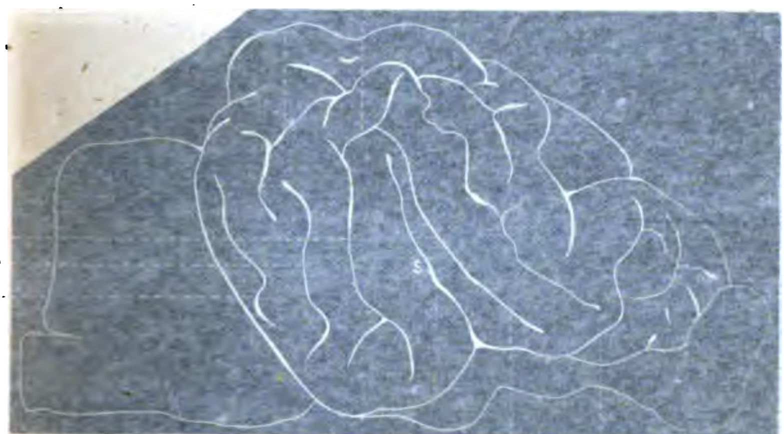


Fig. 10. **Bear: *Ursus Americanus.* ♀ one year. (502.) (p. 2**

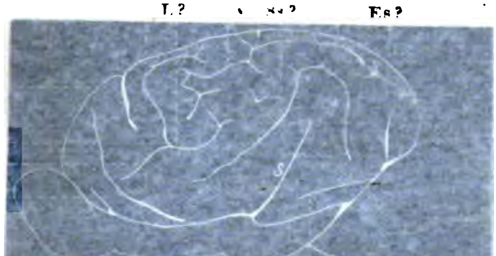


Fig. 11. Raccoon: *Procyon lotor.* Adult. (577.)

[**I am in doubt respecting most of the fissures in *Ursus* and *Procyon.***

Fig. 3. Fox, *V. fulvus.* ♂ adult.

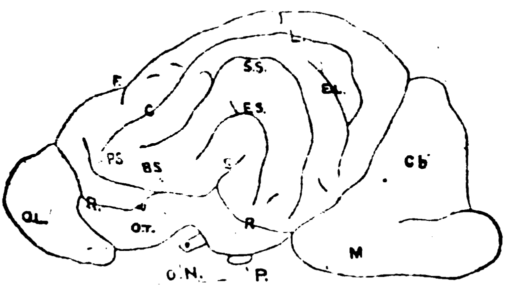


Fig. 4. Fox, *V. fulvus.* ♀ (513.)

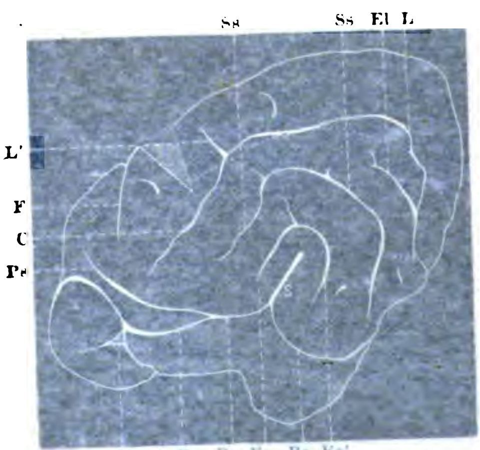


Fig. 5. Fox. Same as 4, projected on a plane. (See page 218, note.)

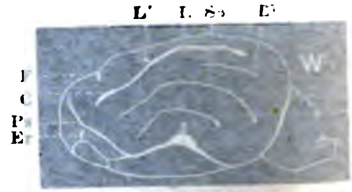


Fig. 6. Fœtal Wolf (*Canis occidentalis*) four days before birth. (530.)

Fig. 7. English Terrier: one day [illegible]

Fig. 8. Weasel. *Putorius Noveboracensis.* Nearly grown. (526.)

Fig. 1. Appendicular lobule of Cerebellum, left side, of Chinese dog. (p. 217.)

Fig. 2. Median lobe [illegible] Kitten (K) and Cat (C) [illegible] during growth. (page 221.)

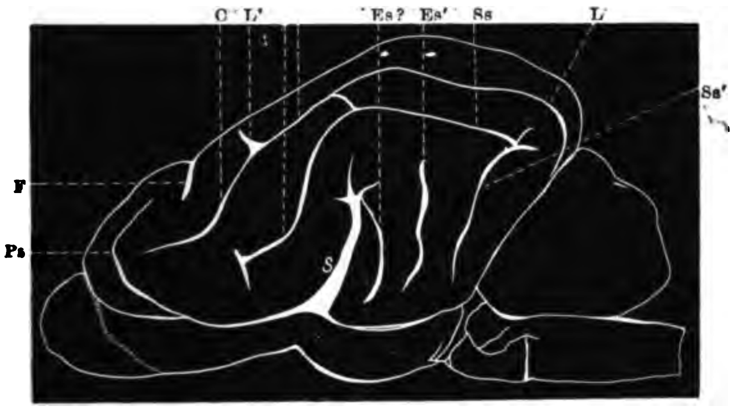


Fig. 9. *Hyæna vulgaris*, ♀ old. (12.) (p. 220.)

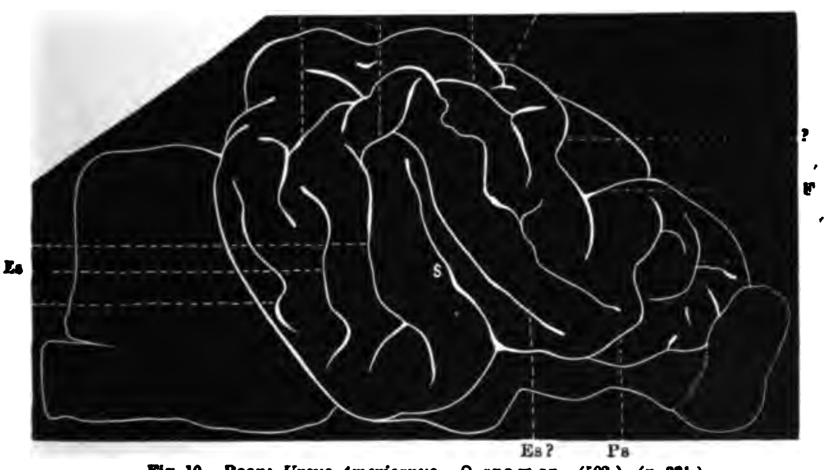


Fig. 10. Bear: *Ursus Americanus*. ♀ one year. (502.) (p. 221.)

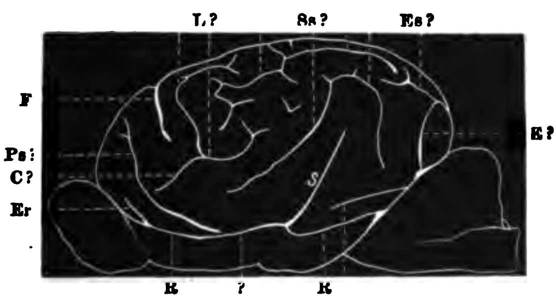


Fig. 11. Raccoon: *Procyon lotor*. Adult. (577.) (p. 225.)

(I am in doubt respecting most of the fissures in *Ursus* and *Procyon*.)

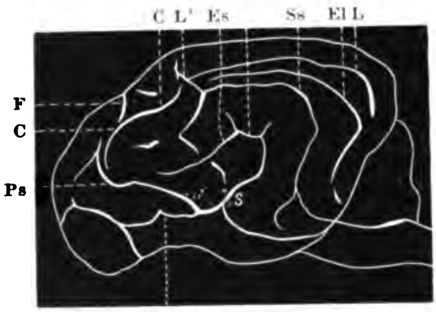


Fig. 12. Small bl'k and tan Terrier, ♀ (left side) six months. (511.)

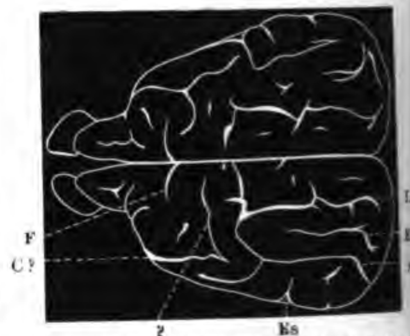


Fig. 14. Young Pointer and Shepherd, ♂

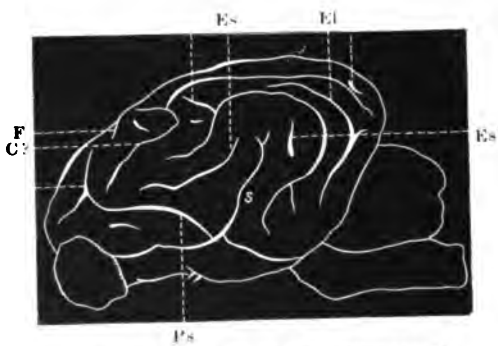


Fig. 13. Same as fig. 12 (right side reversed).

Fig. 15. Cat, Half grown, ♂

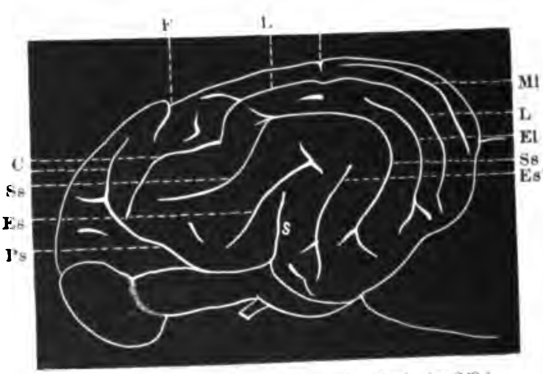
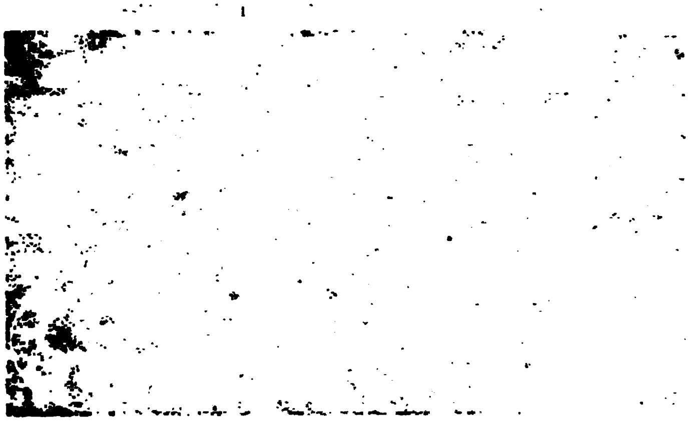
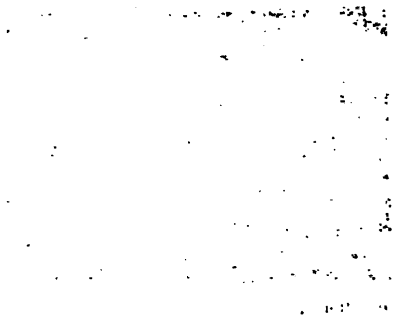
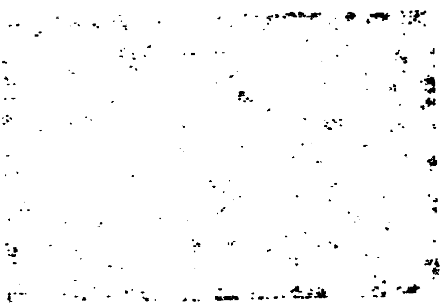


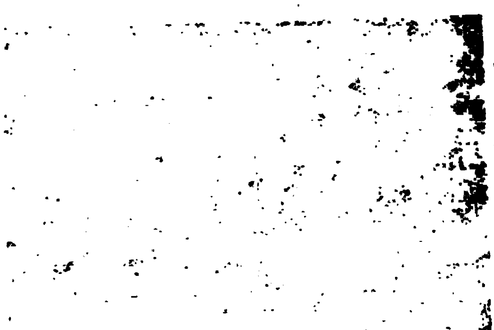
Fig. 16. Greyhound, one year ♂ (526.) (p. 229.)

Fig. 17. Cat, adult. (p. 22









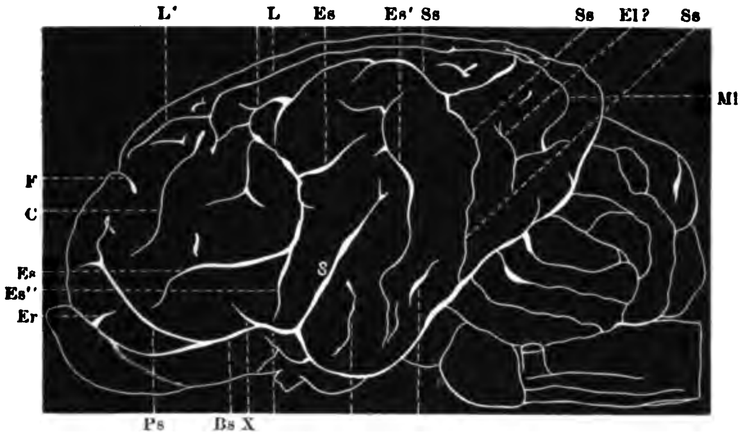


Fig. 18. Lion. *Felis Leo*, var. *Asiaticus*, seventeen months. Cerebellar lobes shown in part. (510.) p. 233.

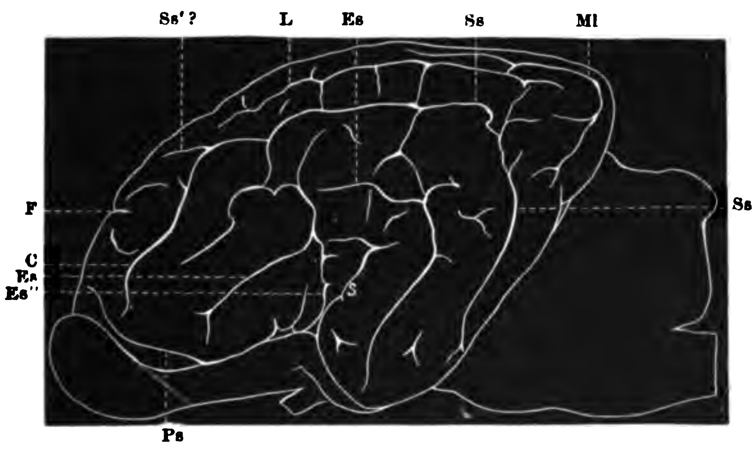


Fig. 19. Lion. *Felis Leo*, var. *Africanus*, ♂ seven and one-half months. Cerebellum in outline only. (552.) p. 233.

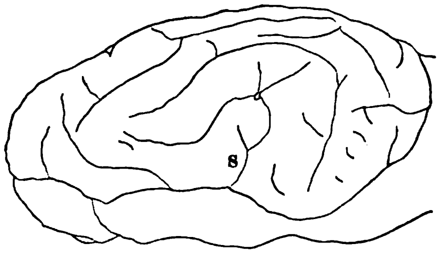


Fig. 20. Pomeranian dog, ♀ adult (1). (Mother of 21, 22, 23.)

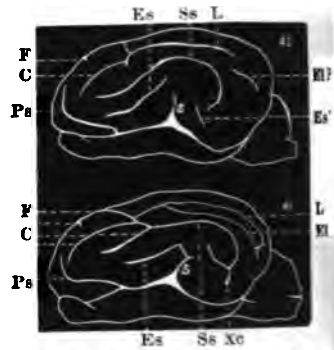


Fig. 24. (41 and 42) Pomeranian pups, ♀ three days.

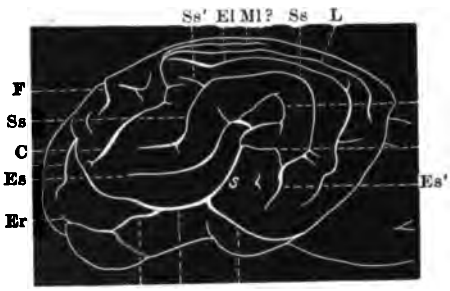


Fig. 21. Pomeranian pup, ♀ five weeks. (3)

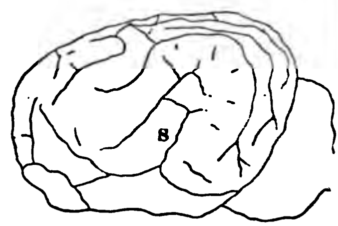


Fig. 22. Pomeranian pup, ♀ four and one-half weeks. (2)

Fig. 23. Pomeranian pup, ♂ fifty-four hours. (4)

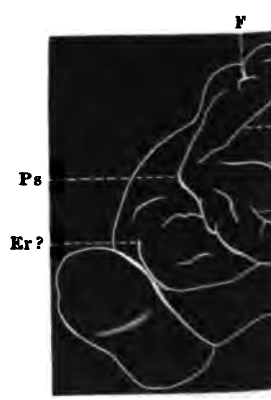


Fig. 26. Newfoundland, ♂ adult. Olf. lobe exposed.

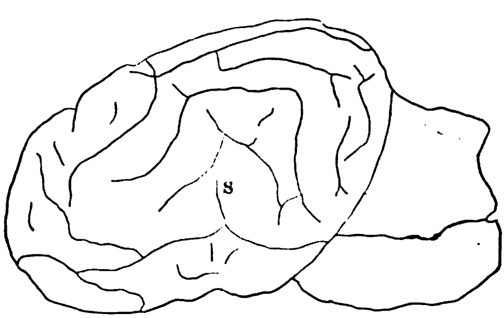
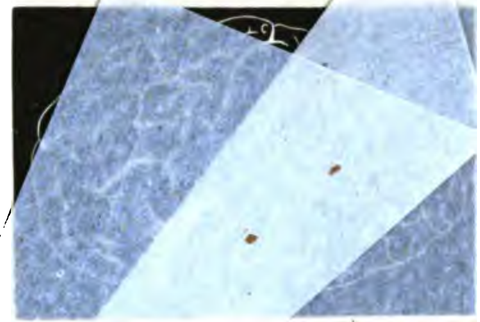


Fig. 25. English terrier, olf. lobe hidden; three and one-half years. (7) (p. 228.)



[illegible] ... hemisphere: weight, ,182.

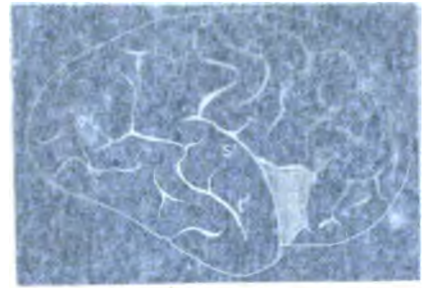


Fig. 2. Left brain, right hemisphere: weight, ,190. (drawn after drying.) See page 250.

Weight of left brain, ,372.

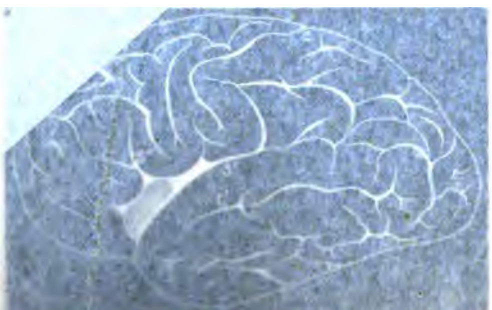


Fig. 3. [illegible] brain, left hemisphere (the dotted line indicating [illegible] which was destroyed): weight, ,136.

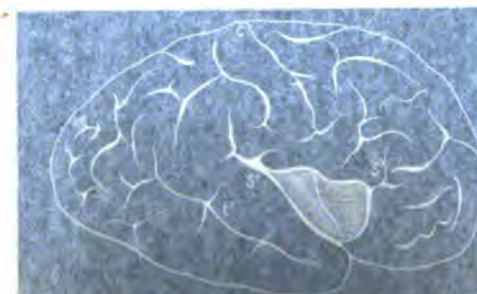


Fig. 4. Right brain, right hemisphere (drawn after drying): weight, [illegible].

Weight of right brain, [illegible].

Fig. 20. Pomeranian [illegible] of 21, 22, 23.)

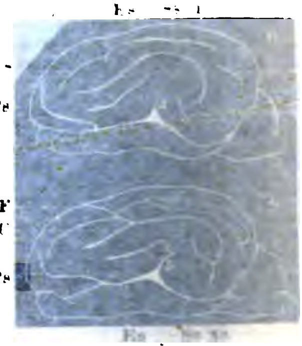


Fig. 24. (41 and 42) Pomeranian [illegible] three days.

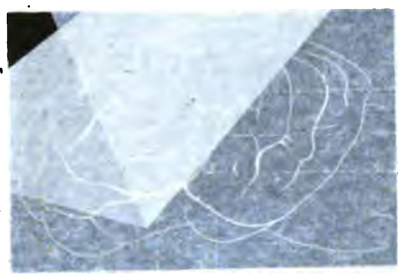


Fig. 21. Pomeranian pup, ♂ five weeks. (3)

Fig. 22. Pomeranian pup [illegible] one-half weeks.

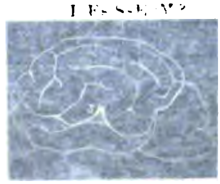


Fig. 23. Pomeranian pup, ♂ fifty-four hours. (4)

Fig. 25. English terrier, olf. lobe hidden; three and one-half years. (7) (p. 228.)

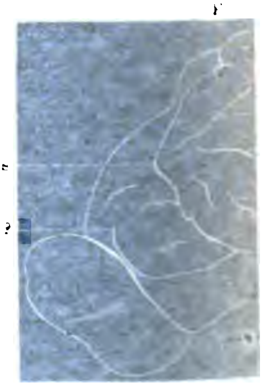


Fig. 26. Newfoundland [illegible] Olf. lobe [illegible]

Fig. 1. Left brain, left hemisphere: weight, ,182.

Fig. 2. Left brain, right hemisphere: weight, ,190. (drawn after drying.) See page 250.

Weight of left brain, ,372.

Fig. 3. Right brain, left hemisphere (the dotted line indicates a part of the frontal lobe which was destroyed): weight, ,196.

Fig. 4. Right brain, right hemisphere (drawn after drying): weight, ,200.

Weight of right brain, ,396.

All the facts indicate that while it is not impossible or even improbable that different areas of the cerebral surface may be in functional relation to either movements or mental operations or both, yet these areas are not *always, if ever, circumscribed by the fissures;* that the fissures merely increase the amount of gray matter wherever they are; their signification being rather quantitative than qualitative.

This question might be decided by Dr. Ferrier's method, exploring not only the free surface of the folds but also the hidden walls of the fissures.

EXPLANATIONS OF FIGURES.*—With two exceptions (Figs. 10 and 13) the brains are shown from the *left* side, and all the drawings are made from specimens hardened, and thereby shrunken, in spirit. The olfactory lobe is given in outline; also the cerebellum and medulla oblongata: but neither the nerve roots, nor the cerebellar convolutions are indicated. As stated on page 218, note, each fissure is drawn as it appears to the eye placed over *it* perpendicularly to the surface on which the brain rests.

Figures 3, 4, 20, 22, 25, showing the fissures dark on a white ground, have been kindly loaned to me by the "N. Y. Tribune," from those which illustrated the report of my lecture on "The Brain, and the present scientific aspect of Phrenology," printed in the "Tribune" Extra, No. 3: a few inaccuracies which could hardly be avoided in the hasty preparation for the press, have been since corrected.

The remaining figures, in which the fissures are shown white on a dark ground, have been drawn on wood and cut by Mr. Philip Barnard of Chicago (now a student in Cornell Univ.), to whose patience and accuracy I gladly bear witness. All the drawings were made by me from specimens which I had prepared.

The fissures are lettered uniformly throughout.

S—Sylvian.	Es'—Its posterior branch.
Bs—Basisylvian.	Esv—Its ventral branch.
Ps—Presylvian.	Ss—Supersylvian.
R—Rhinal.	Ss'—Its medial branch.
Er—Ectorhinal.	L—Lateral.
F—Frontal.	L'—Its medial branch.
C—Coronal.	El—Ectolateral.
Es—Ectosylvian.	Ml—Medilateral.

* The numbers in parenthesis refer to the Catalogue of the Neurology and Embryology of Domesticated animals at the Museum of Comparative Zoology.

Lateral Asymmetry in the Brains of a Double Human Monster. By Burt G. Wilder, of Ithaca, N. Y.

[The figures form plate 6 at the end of the preceding paper.]

It is generally known that the right and left hemispheres often present considerable differences in the details of the cerebral pattern; but very rarely do we find figures or detailed descriptions which indicate the extent of this lateral variation, although its existence would seem a serious difficulty in respect to phrenology. As remarked in a previous paper no brains of different individuals can be so closely allied as those of the same individual, and a study of these must serve to check our estimates of the zoological value of fissural variation between species; next in value for this purpose would usually be ranked the brains of twins or, with animals, brothers and sisters of the same litter; but an intermediate stage of relationship is presented by double monsters, like the one described in the next paper, and as their brains are rarely preserved or figured, I have thought them worth recording.*

The brains were bisected soon after extraction; each was weighed and each cerebral hemisphere placed in spirit upon its mesial surface; being quite soft, they became unnaturally flattened in the process; they were drawn after hardening and the two right hemispheres shrank while drawing, from evaporation of the spirit, so as to lessen their area and to expose the island of Reil to an unnatural extent, as appears in figures 2 and 4. This prevents the otherwise interesting comparison of the four hemispheres in respect to the *length* of the fissures, without reference to their depth; and in respect to the total area of the outer surface of the hemispheres.

But the fissures themselves and their connections are unchanged, and certainly present some striking differences whether the two brains are compared together, or the two halves of the same brain. I have lettered only the *sylvian* (S′), its *ascending branch* (S″), the *first temporal* (t′); and the fissure of Rolando or *centralis* (C).

The temporal (t′) of the right brain, left hemisphere, is in two portions, the separation occurring at a point corresponding with a transverse fissure in the other hemisphere; and although Ecker

* I hope on a future occasion to present a detailed comparison of the four hemispheres of several double-headed calves and pigs, which are now in the Museum of the Cornell University.

says nothing of it (*op. cit.* 62), yet some fœtal brains in my possession indicate that there may here be two fissures which originate separately but usually unite; the case may be compared with that of the *lateral* and *coronal* in *carnivora*. (See page 227.)

I do not feel sufficiently sure of the correctness of the generally received designations of the other fissures to compare them individually, but it is evident that all the fissures differ greatly as to length, direction, branches and connections, and that the smaller fissures vary considerably in number, giving an *appearance* of fissural complexity in the following order. 1. Left brain, left hemisphere; 2. Left brain, right hemisphere; 3. Right brain, right hemisphere; 4. Right brain, left hemisphere.

It is worth noting that, excepting with the left brain, right hemisphere, this order is inversely to that of the weights, as if by way of compensation; also that the two hemispheres of the left brain present the two extremes of fissural complexity, while the intermediate conditions are seen in the right brain.

Furthermore, it may not be too much to associate the greater weight (,024. grams) of the whole left brain over the right, with the fact that the corresponding part of the double body is larger than the right, and the median third leg is thrown over toward the right side, as if it were more fully a right leg of the left child than a left leg of the right child.

The combined weight of the two brains is ,768. which is to that of the bodies, 5,000. about as 1 to $6\frac{1}{2}$, which is the average ratio in females at birth, according to Tiedeman; that in the male being, according to the same authority as 1 to 5·85; as quoted in Quain's Human Anatomy, ii, 570. This monster is apparently of the male sex.

The Papillary Representative of Two Arms of a Double Human Monster, with a Note on a Mummied Double Monster from Peru. By Burt G. Wilder, of Ithaca, N. Y.

The double monster here referred to was still-born, *at term*, in March, 1873; aside from the malformation it was of good size and appearance; the left spine was found to be fractured, and

it may have died during parturition which was long and difficult, although the mother recovered without trouble.

Having preserved all the viscera (including the brains, which were described in the previous paper), it is my intention to prepare a detailed account of the case in connection with several other double monsters in my possession, so I will merely mention that it weighed about 5,000. grams (about eleven pounds), and measured about twenty-two inches when the legs were extended.

There are two stomachs, symmetrically disposed, as usual in such cases; the small intestines continue independently to near the cæcum; this, the colon and rectum are single, the latter terminating at an imperforate anus, just above (behind) the genitals; there are two hearts, and two pairs of lungs; four kidneys and two bladders; the sex is apparently male, but the testes have not entered the scrotum, and I have not yet looked for them among the viscera.

As seen in the figure, its heads are separate and complete, the right larger then the left, as with the corresponding brains; the opposite limbs and sides of the compound body are somewhat unsymmetrical, the right child seeming to constitute more than half of the whole; the hands and feet are quite well formed but there is an extra right pollex; further details will be given hereafter.

So far this specimen nearly resembles that so well described and figured by Professor Jeffries Wyman in the "Boston Medical and Surgical Journal" for March 29, 1866.*

There is also a third and median and morphologically symmetrical leg coming off from the pelvis, and possessing a partly double foot with a median *primus* (great toe) bearing a nail upon each side, and seven other toes of which four seem to belong to the right, and three to the left, moiety; but this left foot belongs of course to the right child, and the right belongs to the left child which thus claims four and a half of the eight toes.

The leg and foot are less regular and symmetrical than in Wyman's case, and the whole limb is swung out toward the left as if more under the control of the right child, concomi-

* The figure is reproduced in Dr. S. J. Fisher's essay upon Diptoteratology, p. 72, and figs. 53 and 54, the description is there quoted in part, and in full in Prof. J. B. S. Jackson's Catalogue of the Warren Anat. Mus. of Harvard University.

tantly with the greater bulk of the right brain (see preceding paper).

The point to which I wish to call particular attention is the existence of a minute papillary representative of the missing arms, corresponding to the legs which are represented by the fused and median limb; this is a papilla about ·005, in length and slightly constricted at the base; the surface is slightly wrinkled and a few short hairs spring from the tip; it is wholly tegumentary, and its cavity contains only loose connective tissue.

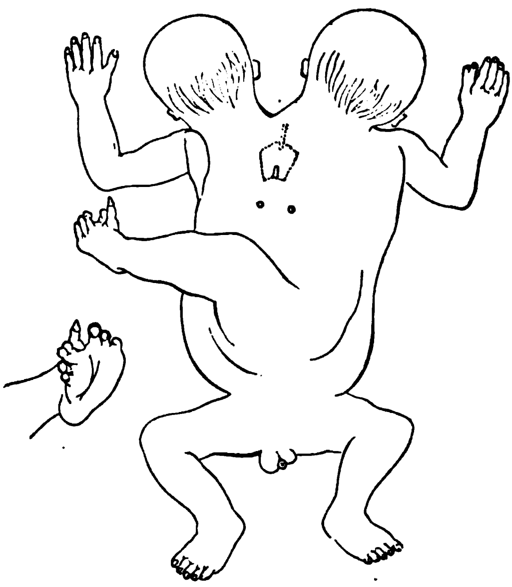


Fig. 1. Dicephalous Monster, from behind; 1-6 of natural length.

Its nipple-like appearance, and its location upon the line of junction of the shoulder regions of the two individuals, suggested its being the result of a fusion of the left nipple of the right child and the right nipple of the left child (the other two occupying their normal positions upon the pectoral regions), but it is *imperforate;* and what is conclusive, the real nipples, though small and hardly projecting from the surface, occupy places upon the sides of the junction-line, the right one (left of right child) being

·030, and the left (right of left child) ·025, behind the median papilla, and at a distance of ·025 apart; an elongated mammary gland underlies the left nipple as indicated by the slight elevation in fig. 2, A, but no such is apparent under the other.

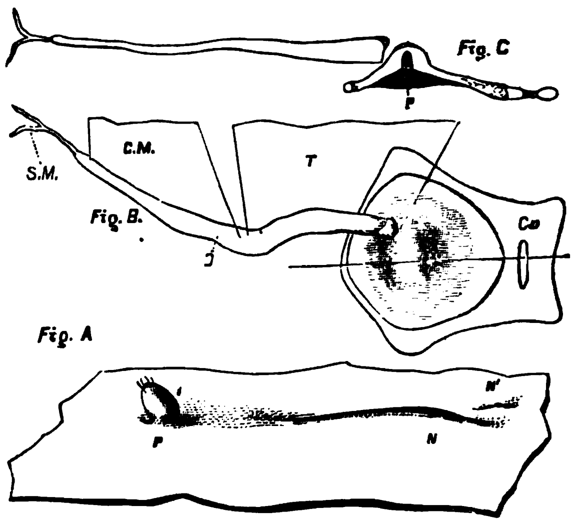


Fig. 2. A. Integument bearing the papillary limb P, and the two nipples N, N'.
B. Median scapula and clavicle from above.
C. The same from the side, the scapula divided near the middle line; all of natural size.

Immediately beneath the integument upon the line of junction are two bones whose position in reference to the papilla is approximately shown by the dotted outline in fig. 1; while their forms and connections are shown in fig. 2, B and Ç. The longer bone is evidently a median and nearly symmetrical clavicle; it is about ·045, in length, is wholly ossified, and presents at its hinder extremity an appearance of epiphysis, which is attached to the anterior slope of the scapular elevation by ligaments, without any synovial capsule; its anterior extremity gives off a slender tendon which bifurcates at a distance of ·005, into the tendons of the two *sterno-mastoid* (?) muscles; into each side are inserted two muscles, the *cleido-mastoid* occupying the anterior, and the *trapezius* the posterior half. The enclosed spaces C M and T

indicate the attached ends of the *cleido-mastoid* and *trapezius* muscles of the right individual; the clavicle is strongly curved toward the left individual, as seen from behind, but as seen from the side its outline is nearly straight, fig. 2, C.

The scapula is a nearly symmetrical disk of bone with a cartilaginous border which is narrow in front, projects as an angle upon each side, and is broader behind where it is closely connected with a transverse bar of cartilage, excepting an elongated gap upon the middle line; the scapular disk is convex upon its dorsal surface, rising near the anterior border into a decided elevation or tubercle corresponding with a deep pit P, upon the concave deep surface, as shown in the section C.

I am not prepared to express a decided opinion as to the nature of the cartilaginous bar; but have no doubt that the disk represents the fusion of the inner or vertebral or proximal moieties of the left scapula of the right child, and the right scapula of the left child, at a point *proximad* of the glenoid cavities so as to leave only portions of the acromial spines to unite and form the elevation against which the clavicle abuts; to the various borders of the scapula are attached muscles, which seem to represent the two *rhomboidei*, the *serratus magnus*, the *levator anguli scapulæ*, and the *omohyoid;* but as I am still in some doubt respecting the *pectoralis major*, and the attachments of the *teres major* and *latissimus dorsi*, I will defer an account of them to another occasion; when, too, the absence of a sternum and the apparent anomalous direction of the clavicle can be accounted for.

In general, however, it is evident that the condition of things is like that in Prof. Wyman's case, excepting that the separation of the two individuals at the shoulders is less complete; or the union is more so.

The result is to reduce so far the median and third arm, that instead of being obviously and unmistakably such it is a mere papilla which but for its position and its relation to the underlying bones would never be regarded as a limb, much less as two arms; yet it is evident that it is just as much so, *morphologically*, as is the earliest pad-like rudiment of a limb in the developing fœtus; for it is possible to conceive of a complete series of intermediate conditions with Wyman's case at one extreme and this at the other.

It would seem therefore that, in any such system of classifica-

tion of monsters as that proposed by Dr. Fisher, our monster should rank as *Dicephalus, tribrachus tripus; op. cit.*, p. 71.

But the question arises whether the name could be retained in case of a still further reduction, so as to leave no external evidence of a median limb; and while this may be of less practical importance in respect to monsters, yet it is akin to the general problem "what constitutes a digit or dactyle" briefly indicated by me.*

NOTE ON A MUMMIED DICEPHALUS FROM PERU. — Dr. Chas. S. Swazey of New Bedford has kindly allowed me to bring some photographs of Peruvian relics, and among them is one of a human dicephalus, closely resembling our specimen; but as it

is in a sitting posture and shown from in front, the existence of median limbs is merely to be inferred, the left foot is partly hidden by the right, and the three tibial (inner) toes of the right are turned down. It seems, from this, that monsters occurred among the ancient Peruvians, and that they were not consigned to scientific investigation, but duly mummified.†

*Intermembral Homologies, p. 63; Proc. Bost. Soc. Nat. Hist., vol. 14, 1871.

†It is stated in Spencer's "Descriptive Sociology" that the "Huacas," or sacred objects of the Peruvians included twins and monsters.

The Habits and Parasites of Epeira riparia, with a Note on the Moulting of Nephila plumipes. By B. G. Wilder, of Ithaca, N. Y.

The large garden spider with black and yellow abdomen, which is very common in certain parts of the south, and less abundant at the north, was first, so far as I know, described and figured only by Hentz.*

Although that author's description is very brief, the spider is readily identified, and it may be better to defer a fuller description until a male is secured; at present there are some points in its economy worthy of investigation, and I will here indicate them, first quoting in full Hentz's account of the species.

"*Description.*—Black, cephalo-thorax covered with silvery-white hairs; abdomen barred with bright yellow spots and dots; thighs usually bright rufous at base, except the first pair. Of a large size, seldom small.

Observations.—This remarkable species usually dwells on the margin of waters where it makes a web of strong threads, in which large *Libellulæ* and *Melolonthæ* are often caught. The abdomen of the female is flat in the early part of the season, and it is not till August that, being distended with eggs, it assumes the oviform shape. Its cocoon is conical, as large as a small plum, like a pear hanging down. Whenever opened it was found full of young spiders instead of eggs. Is it viviparous?

Habitat.—The United States."

During the war I had the opportunity of studying certain features in the economy of this species, which at the time, I imagined to be wholly undescribed, and in "Harper's Monthly" for March, 1867, under the title of "200,000 spiders," I gave descriptions and figures of the female *E. riparia*, of her net and of the cocoon; also of presumed ichneumonidian and chalcidian parasites found therein. And as nothing has since appeared respecting it, I will here give an abstract of the above mentioned paper, together with some additional observations respecting the escape of the young from the cocoon.

* Boston Journal of Natural History, 1847, v, 468, pl. xxx, fig. 5, under the name of *E. riparia*.

On the 21st of March, 1865, on James Island, just south from Charleston, South Carolina, I found suspended in a bush a pear-shaped cocoon (fig. 1), like that described by Hentz. Between

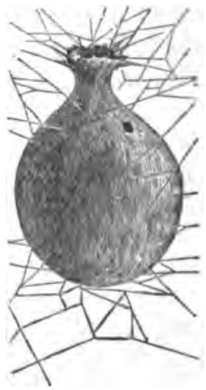


Fig. 1. Cocoon of Epeira riparia; nat. size.

the above date and April 2d, I found in the same locality, and chiefly near a ditch, two hundred and five similar cocoons.

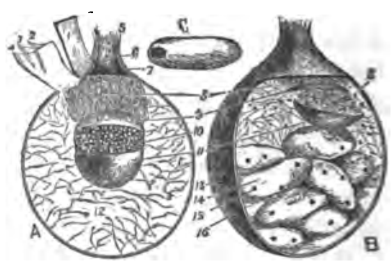


Fig. 2. A. Vertical transverse section of cocoon of *Epeira riparia*, containing only the eggs of the spider.

B. The same showing the cocoons of the ichneumon, which destroyed the eggs, and which are themselves destroyed by chalcidians.

C. Cocoon of ichneumon from which the insect has escaped.

1. Outer, and usually glazed, coat of the cocoon. 2, 3, 4. Second, third and fourth, or inner coats, separated from each other. 5. The pedicel. 6. Looser interior of pedicel. 7. Thickened base of pedicel. 8. Suspensory of the egg-cover. 9. The egg-cover. 10. The eggs partly exposed by separating the cover from the cup. 11. The cup. 12. Loose silk surrounding the cup. 13. Hole made by escaping ichneumon. 14. Ichneumon cocoon. 15. Holes in the ichneumon cocoons made by the chalcidians. 16. Corresponding holes in the spider's cocoon.

The cocoon is usually pear-shaped, ranging from ·015, (15 millimeters) to ·022, in transverse diameter, and from ·025, to ·032, in length. The wall averages ·000,5 (½ millimeter) in thickness, and usually consists of four concentric and closely united coats or layers of silk, which are nearly equal in thickness and compactness, the outer one (1), however, being usually smoothly glazed without, so as to crackle like thin paper; sometimes there are but three coats, and in some of these cases, the outer one is not glazed but soft and velvety; the coats thin out over the pedicel, but not by well-defined edges.

At the top of the cocoon is a *pedicel* or *stem* (5), hollow and loose in texture (6) above, but broader and denser below, where it is concealed by the body of the cocoon, and having its lower surface or base very firm, like a silken disk (7).

The contents of the cocoon are a mass of loose, reddish silk (12) attached above, about the base of the pedicel and apparently also to the inner coat (a special portion of this loose silk, like a *cushion* (8) attached to the base of the pedicel); a kind of *saucer* (9) of very delicate silk, which is inverted, and suspended by the cushion above mentioned; a *cup* (11) of the same delicate silk suspended to the lower border of the saucer (which thus forms its cover) by a few fibres of loose silk; a mass of *eggs* (10), from five hundred to two thousand two hundred in number, enclosed within the cup (at the time these were found, these eggs had evidently hatched, for in their place were found large numbers of little fragments of broken shells); many little round bodied spiders, never, in the earlier weeks, less than five hundred in number; which, when the cocoon was opened, came tumbling out, each swinging by its own little thread, and "looking like so many chickens hung by their tails" (Harper's Magazine, 1866, p. 452, and fig. 12).

I have never witnessed the making of a cocoon; a spider afterward taken near Boston, Mass., was just finishing her work at 6 A.M. of Sept. 26, by attaching lines from the cocoon to surrounding objects. But it may be inferred that the pedicel is first formed, and firmly secured by strong lines in all directions excepting downward; that to its lower surface the spider affixes the cushion of loose silk; and to this the inverted saucer; the eggs are now expressed upward into this, while the spider hangs back downward below it; the cup is now formed under and about the eggs; and then around the whole is spun the loose mesh of silk

which serves the double purpose of protection to the eggs and the spiders, and as a primary habitation for the latter before they escape and make nets of their own; finally, the outer wall is formed in three or four consecutive layers, and the cocoon is braced by strong lines passing to the surrounding twigs.

From the above account it appears that the cocoon must be formed and the eggs laid in the previous summer; and that in South Carolina, the eggs are *hatched as early as the 21st of March;* but although by opening a cocoon every day or two, I satisfied myself that each of them did really contain from five hundred to two thousand living spiders, and although they were kept exposed to the sun and occasionally sprinkled with water, yet during all the time I kept them, namely, until June 15, *not one of the entire cocoons was opened by the inmates.* On and after the 10th of May, however, they sometimes came out of holes cut in the cocoons, or through openings, hereafter to be described. But first it is important to state that from a single entire cocoon found at Ithaca, N. Y., the spiders escaped through a hole made by themselves near the base of the pedicel, on the 14th of June, 1873; so perhaps, but for an accident which destroyed them, those at the south would soon have made their way out.

The fact, however, remains that the young of *Epeira riparia* live together for many weeks in a confined space, and with no *food excepting one another.** That they do eat each other is certain; first, because in cocoons opened later in the season, the spiders were found to be fewer in number, but larger in size; and second, because they were seen to do it, even when out of the cocoon and supplied with other food (as blood) which they seemed to relish. There never was any fighting, however; the smaller and weaker seemed to understand that for the good of the species (*pro bono publico*) they must be devoured by the larger and stronger, who performed their part "doucement et sans cholere."

It is evident that here is an opportunity for noting the working of "natural selection," upon a large scale; for out of the five hundred young who are hatched, comparatively few can reach maturity, else the country would soon be overrun with them; the fact being that although the species is widely distributed, yet I

*Three cocoons of this species were brought to me Feb. 26, 1874; and the young spiders are hatched; without speculating as to the time that may have already elapsed since the hatching, this gives us nearly four months during which the young remain confined; and it will appear that the cocoon itself must keep out the cold as efficiently as the egg shells, pupa cases and cocoons of insects which appear later in the season.

never found them in such abundance in other parts of the south, and saw only eight cocoons between Charleston and Eutaw Springs, South Carolina, searching the woods bordering the road both going and returning.

Of the four hundred and six cocoons obtained on James Island in the spring of 1865, only one hundred and thirty-four were *entire*, and presented no opening whatever. My notes state that one hundred and ninety of the others were *pierced*, but by what is not mentioned and I do not now venture to conjecture; but no spiders came out of these before May 10, although the openings were certainly similar to those made by the spiders in the cocoon mentioned on page 260.

Of the remaining eighty-two cocoons, fifty-nine were *torn*, in one or more places, and through the rents projected loose silk; having once "seen a little bird about the size of a sparrow, fly at a cocoon hanging in a tree, make one or two quick pulls and then retreat," I am inclined to think all these rents were so caused; and as these attacks would usually open the cocoon without injuring the inmates, I drew the inference that this might be a provision of Nature, like the fertilization of flowers by insects, by which the invasion of the cocoon should really permit the continuance of the species; that this is not the only means of egress has been since shown in the case mentioned upon page 260.

PARASITES.—The remaining twenty-three cocoons presented openings of one, and usually of two sizes; the larger about ·001, and the smaller ·000,3 in diameter. Some of these cocoons contained a few spiders, but usually only empty shells; while the original contents were in all cases crowded to one side and upward by a mass of small oblong cocoons (14) of a whitish silk, and more or less firmly united by threads. In one spider's cocoon, some of the smaller cocoons were empty with a hole in one end corresponding in size and location with the larger holes in the spider's cocoon (13); three were entire and each contained fragments of a single insect, apparently an *ichneumon*, of which I have at present no fragments which can be specifically identified. The small cocoons in all the other twenty-two cocoons in this series presented no large holes but instead, many small holes like pin-pricks (15) corresponding to the smaller holes in the spider's cocoons (16); and in all these pierced cocoons were fifteen to twenty little black insects, some motionless (*pupæ*), others crawling actively about

(*imagines*), which are undoubtedly chalcidians, but as yet undetermined; all such cocoons contained also the empty pupa skins of the ichneumons, which, having destroyed the spiders before or after hatching, had been themselves devoured by the chalcidians.

The chalcidians range from ·001, to ·002, in length. The ichneumons range from ·005, to ·006, in length. Their pupa skins from ·006, to ·008, and their cocoons from ·007, to ·010, in length and ·003, to ·004, in diameter.

In the article above quoted, are given figures and descriptions of these parasites and some suggestions as to the manner of their entrance to the cocoon; but it is evident that a careful investigation will be needed in order to elucidate fully the history of this spider and its enemies.

NOTE UPON THE MOULTING OF NEPHILA PLUMIPES.—Mr. Blackwall* has clearly described the moulting of *Epeira calophylla*, and

Figs. 3, 4. Moulting of Nephila plumipes.

called attention to the fact that the first separation of the integument occurs along the border of the cephalo-thorax and not upon the median line. Having witnessed this very often with *Nephila*

*Trans. Linn. Soc., vol. xvi, p. 473, and spiders of Gr. Br., p. 7.

plumipes, I am able to confirm his description; and as no illustrations of the process are known to me, I offer here two representations of *Nephila* drawn by me from the same individual, while partly extricated (fig. 3), and while hanging and drying preparatory to mounting to her net (fig. 4); the position must assist the flow of fluid from the abdomen into the limbs and cephalo-thorax.

I have "biographies" of several individuals of this species which were isolated and watched for a greater or less length of time, in a few cases from soon after hatching to the adult condition; and I have observed remarkable differences of disposition and habit, quite comparable to those commonly ascribed only to human beings and the higher animals; there seem to be truly psychological individualities even among spiders.

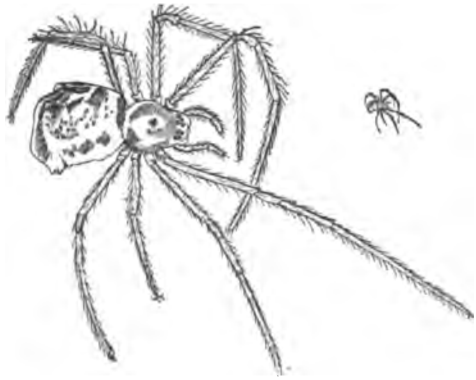


Fig. 5. Nephila plumipes, a few days old; natural size and enlarged.*

Fig. 6. Cocoon of Nephila plumipes, or loose silk attached to the lower surface of a leaf.

*This, with figs. 3, 4 and 6, and fig. 1 of the following paper, are electrotypes of cuts in my article "Memoirs of a Cripple," in "Our Young Folks" for Sept., 1866, furnished me at cost by Messrs. J. R. Osgood & Co.

THE NETS OF EPEIRA, NEPHILA AND HYPTIOTES (*Mithras*). By B. G. WILDER, of Ithaca, N. Y.

MOST *Epeiridæ* ("garden" spiders or "geometrical" spiders) construct a net in the form of a nearly circular disk which is suspended at various angles, but probably never quite vertical or horizontal, although the former position is generally predicated of the ordinary species, and the latter of *Tetragnatha* and some species of *Epeira*. The net consists of a spiral viscid line laid upon a framework of dry radii which converge to a point which apparently coincides with the centre of the disk, but may vary a little therefrom, and, according to Emerton,* is usually nearer the top than the bottom. In some cases, and perhaps in all, the radii are first connected by a *primary spiral dry* line at greater intervals than the secondary viscid line; this is begun at the centre and completed at the periphery, and according to Emerton (*op. cit.*, 479) is removed as the viscid line is laid on (it is permanent in *Nephila*); the viscid line is begun at the periphery and completed near the centre; the spider takes position at the centre upon the lower surface of the net, and always with its head downward. The net of *E. vulgaris* is figured by Emerton (Am. Nat., vol. ii, Pl. 2), that of *E. riparia* by me (Harpers' Magazine, March, 1867, p. 463), and those of several British species by Blackwall, in his great work, "Spiders of Great Britain and Ireland." The net of *Nephila plumipes* † consists wholly and invariably of a series of *looped* viscid lines, laid upon radii which gradually increase in length from the upper to the lower region of the net so that the "centre of radiation" is very much nearer the upper than the lower margin, and is, in fact, more nearly in the upper of the two *foci* of the elliptical net; the radii are very numerous and closely set; secondary radii are placed in the wider intervals commencing at various distances from the centre; and the primary dry line is looped like the viscid line, and is *retained;* the necessity for this extra support being evident from the great size of the nets, which range from one to four feet in diameter, and are strong enough to hold a light straw hat.

The free radii are in the same plane with the others, are always

*American Naturalist, 1868, p. 478.

† As described and figured by me in "How our new Acquaintances Spin," Atlantic Monthly, August, 1866, from which fig. 1 is taken.

in the upper region of the net, and occupy about $\frac{1}{6}$ of its area; they are more irregular than the others, and crossed by irregular lines so as to merge gradually into the outer scaffolding, and are crossed by neither the dry nor the viscid looped lines.

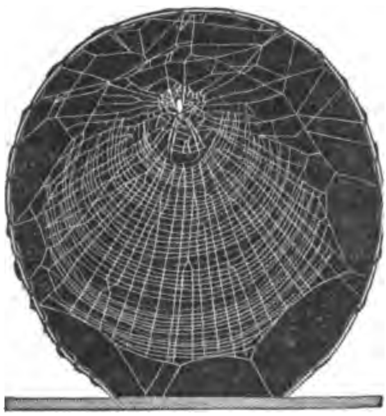


Fig. 1. Net of Nephila plumipes, made in a wire frame, and photographed upon wood; reduced.

In nature, the free radii, as above described, occupy about $\frac{1}{6}$ of the area; but the web of which a figure is given was made upon a wire frame; the limits of which seem to have interfered with the extension of the loops above the level of the centre of radiation.

HYPTIOTES (of Ithaca, N. Y.).—The spider, whose web will now be described, no doubt belongs to the genus *Hyptiotes* Walck. (afterward and more generally called *Mithras*); of which there have been described at least two species, *H. paradoxus* and *H. flavidus*, from Europe, the former having been lately found in Great Britain.*

I refrain from giving a specific name, because if there prove to be only one species in the limited states, we may have to retain the name *cavata* which Hentz applied to the species found by him in Alabama, and to which he gave a new generic name *Cyllopodia*;† Hentz, however, states decidedly that it has but *six* eyes (whereas

* It is my intention to publish shortly a full description of the spider, with references to the synonymy kindly furnished me by Messrs. Blackwall and Cambridge of England, and Wm. Holden of Marietta, Ohio.

† Bost. Journ. of Nat. Ant. 1847, vol. v, p. 466.

my specimens have eight), and his descriptions, both generic and specific, are hardly full enough for identification: he knew nothing of the net. Mr. Emerton has a few specimens of both sexes, taken in Massachusetts, which I have not yet examined critically, but I have not heard of its discovery in other parts of the country.

I have not been able to find specimens of *Hyptiotes* earlier than the middle of September, and they seem to disappear about the middle of November; I have never seen young specimens, but certain little cocoons are very numerous in the same localities, so I suspect them to be made by them.

These cocoons sometimes contain about a dozen egg-shells; in which case the spiders have evidently escaped by pushing up the base of one of the guy lines, which seems fitted like a trap door; sometimes the cocoon is empty, and then the outlet is a ragged hole at one side; and in one I found remains of some winged insect, dipterous or hymenopterous, evidently a parasite as with the *Epeira riparia* (see preceding paper), which may account for the ragged holes in the other specimens.

In some cocoons there are eggs as yet unhatched, and I may succeed in rearing the young.

The cocoons are about ·002, in diameter; and those which contain entire eggs include also some loose silk.

It will be seen that the habits of *Hyptiotes*, and the form of its net, with its mode of construction, are sufficiently peculiar to obviate any danger of confounding it with other genera; I have not yet seen the work of Ausserer in which Mr. Holden thinks the net of the European species is referred to, and do not think any extract from it has appeared in this country, so that a full description of the net may not be out of place.

Specimens of *Hyptiotes* were first found by me in the woods bordering Cascadilla Creek in Ithaca, N. Y., in the latter part of September, 1870;* their dull color, their small size (about ·003,5 in length) and their habits of remaining fixed against the hemlock twig, to which the net is attached, may account for their having escaped observation during the two previous years when I collected in that locality.

This species seems usually to construct its net just before daybreak, and I have only twice observed the process; on the 4th of

* Of about fifty specimens then taken, all proved to be females, nor did I find any males until the 28th of Sept. 1873; these are smaller and fewer in number and make no net, being generally found near that of some female. In this as in previous papers I have added notes since the time of presentation.

October, 1870, I saw the last cross-line (that nearest the apex) finished, and four years later, Sept. 28, 1873, I witnessed the formations of the fine lesser lines: as the process was identical in the two cases, there seems good reason to regard it as normal. Some account of this and of the habits of the spider was given at a meeting of the Cornell Univ. Nat. Hist. Soc., for Oct. 10, 1870, when also specimens of the female were shown. The male was exhibited on the 10th of Oct., 1873, at a meeting of the same society.

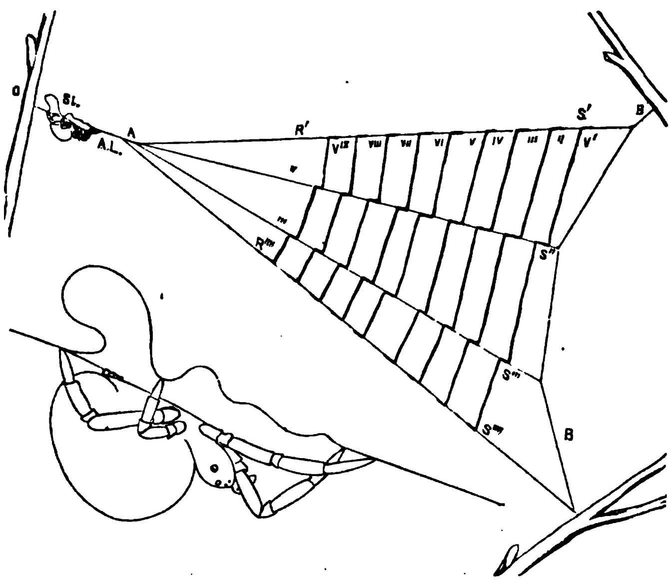


Fig. 2. Net of Hyptiotes "upon the stretch."

BB, base line. A, apex.
O, origin of apex line. R' '' ''' '''' the four radii.
A. L., apex line. V' '' ''' etc., viscid lines.
S' '' ''' '''' Points of attachment of the viscid lines upon the radii; forming little steps upon the latter.
Sl. Slack-line between the first and fourth legs.
This is better shown in the enlarged lower figure, where only the legs of the right side are represented. In the upper figure the spider is shown rather large and the net rather small; the base-line should also be more extended before attaching to the branch at either end.

The net is triangular in form, and consists of four radii, never more or fewer, crossed by several (6 to 10) *independent* viscid lines; the centre of radiation is prolonged into a single nearly

horizontal strong and short line which is attached to a branch or twig; the outer ends of the radii are attached to a second strong line more or less nearly vertical and nearly at right angles with the first.

The radii and base line probably involve no unusual process; but the entire independence of the viscid lines contrasts strongly with the spiral or looped lines of *Epeira* and *Nephila*.

At the time of the second observation above mentioned, the spider had completed the base line, B. B, the four radii (R$'$ $''$ $'''$ $''''$), and the four viscid lines nearest the base V$'$ $''$ $'''$ ^{iv}), she was just then passing along the upper radius (R$'$) from the direction of the apex (A); having reached the viscid line (iv) last completed it turned about, seemed to make some rough measurements of distance with its body, and then, by drawing its spinners along the radius for a short distance (about .002,) formed thereon the same kind of attachment of a new line which I have described and figured in the net of Nephila, and which, though not alluded to by authors, is perhaps generally adopted as much more secure than contact at a single point. The spider then allowed her abdomen to fall away from the radius, hanging therefrom by the first and second pair of legs, and braced away from it by the third pair, she began to move the fourth pair *simultaneously* to and from the mammulæ, so as to extract therefrom a very viscid and elastic line which had a faint yellowish tinge; doing this, she at the same time moved slowly toward the apex, to a point where the interradial spaces were narrow enough to permit her to cross to the second; this she did, ceasing at the same time to draw out the line, which, as she now returned toward the fourth viscid line, contracted considerably, so that it was nearly of the proper length when she attached it to the second radius at a point about as far from the fourth viscid line, as it had been begun upon the first radius; again turning and making the extended attachment as before she repeated the drawing process so as to carry the viscid line to the third radius, and from this to the fourth.

She then ceased drawing the line, and returned to the first radius by way of the crossing (C), began a sixth viscid line, and afterward a seventh, eighth and ninth, all in the same way and at about the same distances apart.

The rapidity of movement of the fourth pair of feet is very

great; by considerable effort I could move one hand at about the same rate, and found it to average, *at least*, five times in a second, or three hundred in a minute; about ten minutes were required to complete these five viscid lines, the time spent in returning being very short; and as the other four and longer lines must have taken at least fifteen minutes, our spider may be estimated to move her hind legs definitely and nearly without cessation about 7500 times in less than half an hour; an estimate which is certainly far within the facts.

I have not yet satisfied myself respecting the exact nature of this viscid line,* beyond the exceeding viscidity and elasticity already alluded to; but I do not think that it is "curled" like that of the *Ciniflonidæ*, as described by Blackwall (*op. cit.*, p. 139), and figured by Miss Stavely (*op. cit.*, p. 114).

[For the rest of the description the present tense is applicable, since it applies to the often witnessed proceedings of many different individuals.]

As soon as the net is completed, the spider takes her position on the apex line (A L) at about an inch from the point of attachment (O) with her head toward the net; seizing the line between the first and second pair of feet, she walks slowly backward, "foot over foot" with the fourth pair, until she reaches the point of attachment (O); into which, or into the line near it, she fixes the fourth pair of feet; this proceeding puts the whole net upon the stretch, draws the second and third radii toward the apex, and thus alters the direction of the base line; the slack line (Sl.), which has now accumulated between the points upon the line grasped by the first and second, and the fourth pair of feet, is held away from the body by the third pair, as seen in the lower figure (only the legs of the right side are shown).

I have not yet measured the strain put upon the net, but it is evidently considerable, yet these spiders remain immovable for hours, like a set spring; so motionless are they, and so compactly placed are the legs, that they look more like projections of the wood than living creatures, and no insect would ever mistrust danger from them. But when the web is struck by an insect, the spider shows that though quiet she is watchful; loosing her fourth feet, the strain is relaxed and the whole net regains its original condition with a sharp snap, which causes the elastic

*An account of this and of the parts concerned in its production will be given hereafter.

lines to vibrate in all directions and generally entangles two or more of them upon the insect; should this first attempt fail, the spider, which has been carried sharply forward with the line, but which has retained her equilibrium by means of the third pair, again walks backward and again lets go; this is sometimes repeated six times in quick succession; when satisfied that her prey is entangled, she advances a few steps at a time, apparently feeling her way (as do the Epeiridæ generally), and approaches the quarry by the nearest radius; the subsequent operations are essentially those of the Epeiridæ, and need not be here described; but in some cases, while advancing toward the prey, she cuts the line with her jaws between her front and hind legs, which allows the net to collapse somewhat; the spider, however, has attached a new line in her rear, so that the continuity is not wholly broken; by repeating this, and cutting all the radii, she is enabled at last to gather the entire net within her front legs and to throw it, like a blanket, upon the struggling prey, which is thereby hopelessly entangled; in such cases, therefore, and, in fact, generally, an entire net is destroyed in making a single capture.

Farther account of its habits would be here out of place, but there are some points to be noted in respect to the plan of the net and the mode of its formation.

1. Unlike both *Epeira* and *Nephila* the number of radii is *constant;* in the hundred or more nets which I have examined, there have been always four radii.

2. But the distances between them, the number of viscid lines and their intervals, like the several dimensions of the net, vary considerably, as shown by the following table.

TABLE OF DIMENSIONS OF THE NET OF HYPTIOTES IN MILLIMETERS; TAKEN FROM TEN NETS.

	Length of apex line (excluding slack).	Length of net from apex to base line.	Width of net at longest viscid line.	Length of space included by viscid line.	Number of viscid lines.
Maximum.....	.150,	.210,	.180,	.150,	13
Mean..........	.035,	.150,	.110,	.110,	10
Minimum......	.010,	.100,	.140,	.075,	7

In fact, the net of the spider, like the cell of the bee, as demonstrated by Wyman, is never the model of geometrical precision which we have been led to believe by superficial examination. I have never yet seen the net of any spider in which the eye alone, unaided by instruments, could not discover irregularities, which, if they existed upon a like scale in human workmanship, would be regarded as serious imperfections. But when it is remembered that insects measure spaces in much the same way that we do, by the eye or the limbs, the only wonder is that metaphysicians and theologians ever ascribed to their work an exactness which men attain only through exceeding care and delicate mensuration.

3. Like the nets of *Epeira* and *Nephila*, and probably all others, the net of Hyptiotes is not vertical but inclined at an angle which varies greatly but is generally more than 45°.

4. So too, the inclination of the longitudinal axis of the net varies greatly. I have never seen the apex-line inclined upward from its origin, but have occasionally seen it slope downward at about 45°; usually the angle is between this and the horizontal.

5. The *independence* of the viscid lines is very striking, but it is evident that the "drawing out" method of this spider would not permit the formation of viscid lines from below upward, without risk of entanglement.

6. The "drawing-out" may impart to the viscid line an elasticity which enables it to shrink to the proper length, after having been long enough to enable the spider to pass from one radius to the next near the apex; it being forced to do this on account of its small size as compared with the interradial spaces; the alternatives would be either—1. To make a larger number of radii, which, however, would increase the resistance to the strain, and lessen the vibrations of the viscid lines: 2. To spin a series of *primary cross-lines*, not viscid, equal in number to the secondary viscid lines, and to use the former as means of crossing while spinning the latter in the ordinary way, then cutting them away as described by some *Epeiridæ;* at present we may hardly conjecture the causes which led to the exclusion of these hypothetical methods, but meanwhile it is to be noted:—

7. That the series of viscid lines must be commenced at the larger and concluded at the smaller extreme, because otherwise either—1. Each succeeding line would have to be engineered by its predecessor which would be between it and the crossing: or,

2. If the spider chose to effect her crossing at the base line, then the shorter lines would have to be carried and stretched the greater distance, and *vice versa;* whereas now, that distance decreases with the length of the viscid lines themselves.

8. The net is *triangular*, the section of a circle, unlike that of any other genus; and, in *idea* at least, may be regarded as filling the vacant space in the net of *Nephila* as compared to that of *Epeira;* so that we may say in mathematical language, *Nephila*+*Hyptiotes*=*Epeira;* in more homely phrase the net *Epeira* is a whole pie, that of Nephila is a pie lacking one-sixth, while that of Hyptiotes supplies the missing piece.

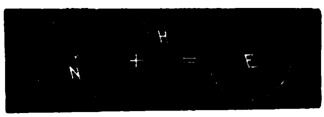


Fig. 2. Diagram representing the forms of nets of *Nephila N.*, *Hyptiotes H.*, and *Epeira E.*

ZOOLOGICAL RELATIONS.—The above comparison of the net-patterns of *Epeira*, *Nephila* and *Hyptiotes* is suggestive, but by no means conclusive; and we need to know much more concerning all of them, especially their embryology, before venturing an opinion respecting their zoological relations: particularly since our highest authority is now inclined to place Hyptiotes among the *Cinflionidæ* (Blackwall Ann. and Mag. of Nat. Hist. 1864, p. 436).

It is worth noting, however, that the gap between the continuous spiral net of *Epeira* and the returning loops of *Nephila* may be regarded as lessened by the following considerations.

1. Mr. Blackwall states that *E. calophylla* "usually employs a radius as a means of communication between its net and a small tubular cell of white silk which constitutes its retreat;" . . . and on reaching this radius it retraces its steps until it reaches a point on the opposite side of the radius, and by repetition of this the net is made to consist of a series of *looped-lines*, "arcs of circles:" it does not appear that this "free radius" is always in the same region of the net, although it is probably one of the upper series, as seen in the figure by Miss Stavely (British spiders, p. 246).

2. In several nets of a small species which is common in Ithaca, N. Y., I have (Sept. 28, 1873) seen the addition of four *looped* lines (like those of *Nephila*) to the lower border of the net; and in May, 1871, I found a deserted net built in an angle which

consisted of fourteen turns of the spiral line which formed the limit of the net upon the side toward a fence post, but on the other three sides (the top, the bottom, and the right side), the net was extended by ten looped lines: this augmentation of the lower region of the net would leave the centre of radiation above the geometrical centre, as Emerton states to be the case (Am. Nat., II, 478) with *E. vulgaris*, but without explaining whether it is due to the addition of independent lines or of loops or the increase of the spaces between the spiral lines.

Now since all these spiders hang from the lower surface of the inclined net, and always *head downward*, it is evident that, for the larger ones especially, it must be very much easier to reach even a distant point below their level, or even at one side, than to turn and ascend; and if it shall prove, upon closer scrutiny than has yet been given, that the true *Epeiridæ* may, upon occasion, and under any circumstances, construct a part of their nets of looped lines, it might be conjectured that a habit thus formed would become confirmed, intensified and transmissible; *Nephila* might in this way be regarded as a derivative from *Epeira*.*

The simple triangular net of *Hyptiotes*, with its uniform number of radii and small number of cross lines, might be regarded perhaps as a further specialization from that of *Nephila*, the circle of the *Epeira* being now reduced from five-sixths to one-sixth of its area, and the dry space above the centre in the net of *Nephila*, represented by a single radius, the apex line; but in some respects it is easier to compare the net of Hyptiotes with that of *Epeira calophylla;* the apex line would then represent the single free radius. The ordinary *Epeiridæ*, as well as *Nephila*, are accustomed to vibrate their nets, when touched by insects, and this habit may be the basis of the remarkable method by which Hyptiotes entangles its prey.

REPAIR OF NETS.—It is known that the *Epeiridæ* renew the entire net occasionally, and they have been seen to chew it, for the purpose, apparently, of extracting the gum. In most cases, the *Nephila* renews only *one-half* of its net, which varies from one to

* A comparison of their forms looks the same way; for the young *Nephila* is round bodied like the *Theridion*, and makes at first a similarly irregular net of lines crossing in all directions; later it passes through the more elongated form of the ordinary *Epeira* and finally attains the almost cylindrical outline proper to its genus. See previous paper.

three feet in diameter; it cuts the net in two vertically, and stuffs the mingled silk, gum and dust between its jaws, chewing it for several hours, and finally rejecting a black and very hard pellet which seems to consist almost entirely of dust; the half of the net thus destroyed is then renewed by looped lines *necessarily;* the next day, the other half may be renewed in like manner.

It would appear that most *Epeiridæ* renew the entire net at once; but it will be worth while to notice whether the larger species do not, like Nephila, renew only one-half at a time, for if so, they must employ looped lines instead of a continuous spiral.

As stated above, the entire net of *Hyptiotes* is usually destroyed in the capture of a single insect; and as the rejected pellet is quite dry, we may infer that the spider appropriates the viscid portion of the net enveloping the prey.

I shall probably propose the name *Americanus* for this spicies of *Hyptiotes;* for although this may be the species referred to by Hents as *Cyllopodia cavata*, yet his description and figure are insufficient for identification.

The Need of a Uniform Position for Anatomical Figures. By Burt G. Wilder, of Ithaca, N. Y.

The convenience of a uniform position for anatomical figures is sufficiently evident to all; and the neglect of such uniformity is a source of delay and even misinformation to beginners. The position with head to the left is advocated partly because it is more natural, in dissection and drawing; partly because the only author, Professor Agassiz, whose figures are uniformly placed, many years ago chose that position, as may be seen in the "Poissons fossiles."

The figures in Huxley's and in Owen's Comparative Anatomy of Vertebrates are often scarcely intelligible, on account of reversed positions, and the larger number of authors seem to regard the matter as of no importance whatever.

Lateral Position of the Vent in Amphioxus and in the Larvæ of Rana Pipiens. By Burt G. Wilder, of Ithaca, N. Y.

The posterior opening of the alimentary canal in *Amphioxus lanceolatus* has been so variously described and figured that a brief historical sketch is here given.*

Historical sketch.—It does not appear that Pallas or Costa or Yarrell remarked any peculiarity in the cloacal region, and I have not seen the earlier papers by Retzius and Müller. Couch (4 (1838) 382) merely states that "the vent is at the length of one-third of the body from the tail," but as in all my specimens the

*The following list probably includes all the important original papers upon this genus; in the text they will be referred to by their numbers as here arranged; the last number will indicate the *page* and the middle one, when it occurs, the *volume*; the list of general works in which Amphioxus is mentioned occurs upon page 278.

Bibliography (special papers).

1. Pallas, Spicilegia zoologica, fasc., xv, p. 19, fig. 11., t.
2. Costa, Annuario zoologico, 1834.
3. Yarrell, History of British Fishes, 1836, p. 468 (2nd ed. ii, p. 618, 3rd ed. i, p. 1.)
4. Couch, Mag. of Nat. Hist. 1838, p. 381.
5. Couch, Fishes of Brit. Islands, p. 415, pl. 248. (date ?).
6. Costa, Fauna del regno di Napoli, 1839.
7. Retzius, Monatsbericht der Academie der Wissenchaften, 1839, p. 197.
8. Rathke, Bemerkungen über den Bau des *a. l.*, 1841.
9. Sundevall and Löven, Forhandl. Skand. Naturf. 2nd möde, Kjöbenh. 1841, p. 280.
10. Goodsir, Trans. Roy. Soc. Edinburg, xv, p. 1 and Ann. of Nat. Hist. vii, 346, 1841: also Anatomical Memoirs, vol. 1.
11. Müller, Ueber den Bau und die Lebenserscheinungen des *a. l.* Abhandl. Ak. Wiss. Berlin, 1842, pp. 79–116, Taf. 1–5.
12. Kölliker, Ueber das Geruchsorgan von *A.* Archiv für Anat. 1843, pp. 32-35, Taf. 11, Fig. 5.
13. Quatrefages, Comptes rendus xxi, p. 519, 1845.
14. Quatrefages, Sur l' *Amphioxus*, Ann. des Sciences Nat. 1845, pp. 197-248, Pl. x–xiii.
15. Gray, *A. belcheri*, Proc. Zool. Soc. 1847, p. 35.
16. Müller, Monats. Akad. Wissen. Berlin 1851, p. 474.
17. Sundevall *(Branchiostoma elongatum)* Oefuers, Vet. Ak. Förhandl. 1852, p. 147.
18. Sundevall *(B. caribæum) Op. cit.*, 1853, p. 11.
19. Max Schultze, Verhandl. Naturhist. Vereins preuss. Rheinl., xix. Sitzungsber. p. 197. Also in Siebold's and Kolliker's Zeitschrift iv, 1852, p. 416, taf. 13, figs. 5 and 6.
20. Kroyer, Danm. Fisk, iii, p. 1,067 (date ?).
21. Steenstrup, Oefuers. Dansk. vid. Selsk. Förhandl. (1863) 1864, p. 238.
22. Marcusen, J., Comptes rendus, 1864, pp. 479–483. Also in Ann. and Mag. of N. H., 1864, xiv, pp. 151 and 319. Also in Rev. et Mag. Zool. 1864, xvi, p. 79.
23. Kowalewsky, Mem. Ac. Sc. St. Petersb., 1867, xi, No. iv, pp. 16, 3 pl. abstract of same in Bibl. Univ. Art. 25, 1866, Bull. Sci. pp. 193–195, transl. in Ann. and Mag. of Nat. Hist. 1867, p. 69.
24. Bert, Comptes Rendu 1867, p. 364 or Ann. and Mag. of N. H., xx, p. 302.
25. Owsjannikow, Bull. de la Ac. Impe. des Sci. de St. Petersb., tome xiii, No. 4. pp. 287–302, 1868.
26. Moreau, Obs. sur la struct. de la corde dors. Comptes rendus, May, 1870, p. 1006.
27. Moreau, Note sur la région cranienne, Comptes rendus, May, 1870, p. 1189.

post ventic region forms only ⅟ or ⅛ of the whole length, Couch probably referred to the "abdominal pore." It is worthy of note, however, that Couch's figure, though rude and in some respects inaccurate, rightly indicates the fact, apparently overlooked by all other observers before and since, that the ventral border of the left muscular mass retreats a little at the cloacal region (as shown in my figures) so as to expose the mesial surface of the right muscular mass or the cloaca itself when distended.

Goodsir (10 (1841) 382) says "The anus is in the form of a longitudinal slit," as appears also in all his figures, one of which is reproduced herewith (Fig. 1. G). These figures have the location of the vent nearly correct in proportion to the length of the body, but the author states that the "anal fin is interrupted at the anus," 375, whereas it is usually, if not always, widest at that point. It must be remembered, however, that Goodsir's observations were confined to *two individuals*, and his dissections to but *one* of these, and while correcting his errors, we are more inclined to wonder at the amount of new information which he obtained from so scanty material.

Fig. 1. G. Hinder part of *Amphioxus*, from below; copied from Goodsir, Pl. 1. Fig. 4.
M. The same, from the left side; copied from Müller, 11. Taf. 1. Fig. 1.
Q. The same, from the left side; copied from Quatrefages, Pl. xiii, Fig. 1.

From his second paper (11, 1842) it appears that Müller had plenty of material; he rightly locates the vent opposite the broad part of the caudal fin (as seen in Fig. 1, M) making the intestine project slightly as a narrow tube with oval orifice; his description is as follows (translated): "The vent lies on the left side of the abdominal fin; this anomalous position of the vent upon one side of the anal fin recalls a similar peculiarity with *Lepidosiren*;"* both figure and description show therefore that Müller supposed the vent of Amphioxus to differ from that of most vertebrates, merely in its lateral position, and no allusion is made to the peculiarity in the concluding general remarks.

* It will be seen hereafter that in this genus the condition of things is quite unlike that in *Amphioxus*.

In the somewhat extended paper of Quatrefages (14) it is not easy to separate his own observations from his summary of preceding ones; as seen in Fig. 1, Q, the vent is the oval orifice of a simple tube which opens far in advance of the expanded caudal fin, which also is shown rather shorter than is natural; as in Müller's figure, however, the vent is correctly shown to the left of the "abdominal segmented canal."

Quatrefages' description (translated) is as follows: "The anus lies at a point where the membranous border enlarges into a lancet form, it opens upon the left side of the abdominal surface of the body, close to (*tout auprès*) a membrane which occupies the median line." p. 201.

Later observers seem to have overlooked the "anomalous location of the vent," referred to by Müller and Quatrefages.

The formation of the anus, by a gradual constriction of the borders of the "secondary cavity" is described by Kowalewsky (23, pages 3, 4, 5, 7); the figures of the earlier stages indicate that the anus is median; some of the later ones show it as if on the left and others as if on the right side; but the text nowhere refers to any unsymmetrical position, which is the more noteworthy because attention is called (10) to the unsymmetrical character of the *oral* aperture.

We may conclude that our author, while no doubt well aware of the general opinion respecting the vent of the adult, did not under-

Fig. 2. (copied from Kowalewsky. Entwick. des *Amphioxus*; the caudal region of the embryos shown in Fig. 22, 23 and 28, corresponding to A, B and C, respectively.

A. An embryo of sixteen hours, seen from above, showing the outline of the intestine which narrows and opens at the anus *a* apparently upon the *dorsal* region of the body, with a single series of ciliated epithelial cells behind it.

The letters R and L are added better to designate the relative position of parts.

B. An embryo of twenty-four hours, seen from the *right*; a, the anus which appears to open on the right side of the body.

C. An older embryo seen from the *left*, on which side the anus appears to open; and this is the more confusing from the considerable backward extension of the caudal region.

No reference is made in the text to the exact position of the orifice.

take to elucidate the manner in which this condition was reached; although, had he so chosen, his opportunities and the skill elsewhere displayed, would have enabled him to clear up the obscurity which now rests upon it.

Most systematic works and zoological text-books* published since the discovery of *Amphioxus* include more or less complete accounts of its structure; but as their authors have not published separate papers upon the subject, one can only conjecture the extent of originality in their descriptions.

The recent and very complete work of Claus (51) states that the "vent is somewhat laterally placed;" and further (p. 830) that the development (according to Kowalewsky) involves "striking asymmetry with respect to the mouth, vent," etc.

Schmarda (52, 302, fig. 501) gives a somewhat altered copy of the figure from Quatrefages, but no reference to the vent.

Huxley (55, p. 117) says that the "anal aperture is a little to the *left* of the median line," yet his figure, apparently copied from Müller, is *reversed* so as to bring the vent upon the *right* of the anal fin.

Troschel (59, 284) says that "the fin passes to the right of the vent."

Owen (56, 1, 31, fig. 23) gives a purely diagrammatic figure of the organs of *Amphioxus*, in which the intestine opens on the median line, and the text contains no allusion to a peculiarity in that region.

Clark (60, fig. 226) copies Owen's diagram without comment; and Gegenbauer (53, 788), in like manner, copies Quatrefages, merely saying (p. 799), "Die Cloaken bildung fehlt bei *Amphioxus*."

Hæckel offers a figure (61, Taf. xiii), which mainly resembles

* SYSTEMATIC WORKS (arranged in no special order).

51. Claus, Grundzuge der Zoologie, 1872, 828.
52. Schmarda, Zoologie, 302, fig. 501.
53. Gegenbauer, Vergl. Anat., 1870, 778, fig. 256.
54. Rolleston, Forms of Animal Life, 1870, lxxxiv.
55. Huxley, Anat. of vert. animals, 1871, 116, figs. 28 and 29.
56. Owen, Comp. Anat. and Phys. of Vert. 1, 31, fig. 23.
57. Agassiz and Gould, Principles of Zoology, 1848, 181, fig. 158. (Shows correctly the position of vent.)
58. Vander Hœven, Hand book of Zoology, 56, 1858.
59. Troschel, Handbuch der Zoologie, 1871.
60. Clark, H. J., Mind in Nature, 1865.
61. Hæckel, Natürliche Schöpfungsgeschite, 1872.
62. Gunther, Catalogue of Fishes in the British Museum, vol. viii.

that of Quatrefages; and Gunther (62, 513) enumerates, among the generic characters, "a low rayless fin runs past the vent;" so far as I know the point is not alluded to by other systematic writers.

It appears therefore that to many the lateral position of a normally median primary opening seems to require no mention, and that when the asymmetry is alluded to, it is not certain whether the vent is lateral and the fin median, or the reverse.

The reception of a large number (about one hundred and fifty) of specimens, well preserved in spirit,* and the subsequent opportunity of examining sixty specimens from the coast of Florida, belonging to the Museum of Comparative Zoology,† have enabled me to investigate this point quite fully.

Nothing of the exact structure of the vent‡ can be made out with the naked eye; in addition to the dissection of many individuals under the lens, I have made about two hundred microscopic sections of the cloacal region; and the following account is based upon their careful and prolonged comparison.

It would be more amusing than instructive to enumerate the many and different opinions successively formed in the course of this investigation before the present conclusion was reached, and while admitting the possibility that the true condition of things is not yet known, I shall ask of the critic to state the amount of material upon which his contrary opinion is based. I am well aware of the insufficiency of both figures and description, especially in respect to the minute anatomy of the tissues; upon some of these points I have nearly made up my mind; but as all of them are more or less involved in the general structure, and some of them are quite differently represented by different authors, it seems

*Collected at Naples and sent by mail by my friend and former student, W. S. Barnard, S. B., Ph. D.

†Just as this paper is going to press, Prof. Putnam has kindly loaned me two specimens from the Florida coast which agree so entirely with the specimens belonging to the Mus. of Comp. Zoology, and are so immediately distinguishable from the Naples specimens, in form and in the proportions of the regions, that I feel almost assured of the specific distinctness of the *Amphioxus* from the two localities; but, as will be explained farther on, no conclusion upon this point can be regarded as reliable unless based upon the accurate measurement of many specimens, and the enumeration of the segments composing their different regions: this will take time, but will be done as soon as possible.

‡The terms *cloaca* and *vent* are here used provisionally; at present, notwithstanding all that is known of the different morphological and physiological relations of the alimentary, urinary and generative outlets in vertebrates, as briefly stated by Huxley, 109, 131, 138, the above terms are not clearly discriminated from *rectum* and *anus*.

better to defer a discussion of them until the completion of the study which I am now making of the entire organization of this lowest, and in most respects, anomalous vertebrate. This paper may be regarded as a preliminary notice of a single part of the subject.

Fig. 3. A. *Amphioxus*; seen from the left, natural size; V, the vent; A P. The abdominal pore.
B, C, D. Transverse sections at middle of body to show different conditions of ventral wall in different individuals.
B. A cross-section of the body at the middle of its length, showing the "abdominal groove."
C. The same of a Florida specimen, in which the abdomen is flat, or but slightly convex.
D. The same of a Naples specimen, full of eggs, in which the abdominal groove is obliterated.

The simplest presentation of the subject will be an explanation of the figures.

Fig. 3 shows an *Amphioxus* (from Naples) of the natural size, head to the left; no details of structure are given, but there is no question respecting the existence of an expanded vertical fin around both ends of the body; the notch V indicates the location of the vent, and the notch AP the location of the abdominal pore.

Most of the Naples' specimens present the abdominal groove described and figured by Müller as formed by two lateral folds of the integument extending from the mouth to the abdominal pore (Fig. 3, B);* a specimen sent from Naples by Prof. Panciri to the Museum of Comparative Zoology is distended by the enlarged reproductive organs, and these folds are *wholly obliterated*, together with of course, the groove (Fig. 3, D); and most of the Florida specimens (taken in May), in which the reproductive organs are less bulky, have loose ventral parietes, as if regaining the grooved condition during the gradual discharge of the reproductive products (Fig. 3, C); so it is quite possible that the folds and grooves are periodical appearances for the accommodation of the reproductive development.

Position of the Vent.—The position of the vent with respect to the fin and length of entire body is very differently represented

* A similar groove exists in the male pipe-fish (*Syngnathus*) but is located *behind the vent.*

by Müller and Quatrefages; in all my Naples specimens the vent is as in Müller's figure opposite that part of the fin which first gains its greatest depth, passing from before backward or just before it begins to decrease in depth, passing from behind forward.*

In one of the larger specimens from Naples .045, in length (about two inches) the vent is .005, from the tip of the tail, and the abdominal pore .009, in front of it, or .014, from the tip; the latter opening is therefore about one-third of the length from the tip and the former one-ninth. Or, assuming the length of the body to be 100, the post poral region is .31 and the post cloacal region .11.

Müller's figure yields the following ratio, post poral region .13, post cloacal region 4, while according to Quatrefages' figure the post poral region is .41 and the post cloacal .23. But as one of the Florida specimens, .043 in length, gives the same regions as .25 and .9 respectively, we may infer the existence of considerable variation. It is my intention to present a large series of accurate measurements of specimens from various localities as one element in the determination of specific or variety differences.

TABLE OF PROPORTIONS OF AMPHIOXUS, AS DERIVED FROM SPECIMENS FROM NAPLES AND FLORIDA, AND FROM THE FIGURES OF MÜLLER AND QUATREFAGES (IN MILLIMETERS).

	Total length.	From vent to tip of tail.	Ratio to whole length.	From abdom. pore to tip of tail.	Ratio to whole length.
Naples....	.045,	.005,	.11	.009	,31
Florida..................	.043,		.09		,25
Müller................			.04		,13
Quatrefages.............			.23		,41

THE VENT AND THE FIN.—Leaving out of view for the present the absolute position of the vent with respect to the median line,

*In many alcoholic specimens, especially those from Naples, the fin is carried to the left and as it were wrapped over the entire cloacal region (as indicated in the Fig. 6 C) and this in connection with the peculiarly protected orifice of the vent, the sharpness of the tail, and the suspected existence of a caudal sense organ suggests the possibility of occasional retrograde locomotion.

it is desirable to confirm the general opinion that it lies to the *left* of the *abdominal* (*caudal or anal*) *fin*.

I first selected, at random, fifty specimens from the Naples lot, and carefully introduced a black bristle into the vent. The naked eye can hardly detect a difference between the two sides of the cloacal region, but the bristle would never enter the right side, while, by a little preliminary movement to the right (the necessity for which will appear farther on), it readily entered upon the left side of the fin.*

Forty more of the same lot were examined in other ways either by section or dissection, with the same result. All of the sixty Florida specimens were afterwards examined, and the vent found to open always upon the *left* of the fin.†

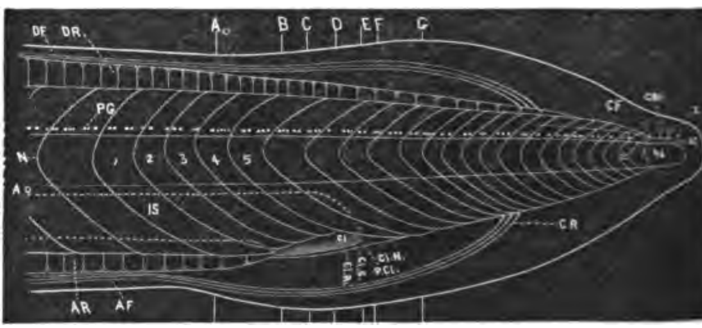


Fig. 4. Hinder extremity of *Amphioxus*, magnified about ten diameters. (For fuller explanation, see the text and the explanation of the lettering upon the next page.)

We may fairly conclude from these one hundred and fifty specimens, that in the *Amphioxus* of the Mediterranean and of the Florida coast, the vent opens to the left of the abdominal fin; and that exceptions will probably be as few as are the cases of transposition of viscera with men, and not to be compared with the exceptions to the rules as to "blind sides" among *Pleuronectidæ*.

*In order to avoid some errors into which I was led, I would add that specimens so treated, however carefully, are not fitted for sections or for minute examination of the cloacal region; the cloacal valve is apt to be ruptured or distorted, and the pressure of the bristle unnaturally prolongs the cloacal notch.

† These specimens are less well preserved than the others, and either from this cause, or from a difference in the natural width of the body (into which I shall inquire with a view to possible specific difference), it is easier to see the parts with the naked eye or a feeble lens.

The following explanation of the lettering applies to all the figures of *Amphioxus*.

Ao — Aorta.
AC — Abdominal cavity.
AF — Abd. fin (anterior to caudal expansion).
AFo — Abd. folds.
AG — Abd. groove.
AL — Abd. lamina (lateral).
AMS — Abd. median septum.
AR — Abd. ridge.
AS — Abd. segmented canal.
AP — Abd. pore.
B — Basement membrane.
Cl — Cloaca.
ClR — Cloacal ridge.
ClN — Cloacal notch.
ClS — Cloacal sinus.
ClV — Cloacal valve.
ClA — Cloacal aperture or vent.
CF — Caudal fin.
CR — Caudal fin rays (only *three* shown above and below).
CNe — Caudal nerves.
CC — Central canal of spinal cord.
Ci — Cilia.
DF — Dorsal fin (anterior to caudal expansion).
DR — Dorsal ridge.
DFi — Dorsal (posterior) fissure of spinal cord.
DS — Dorsal segmented canal.
F — Fæces.
HNA — Hyperneural arch.
HNC — Hyperneural canal.
I — Intestine.
IC — Inner (mucous ?) coat of intestine.
IS — Intermuscular septum.
ICC — Inner (mucous ?) coat cells.
M — Mesentery.
MC — Middle (muscular ?) coat of intestine.
My — Muscular mass.
N — Notochord (the thick wall of the tube).
NS — Notochordal sheath (of connective tissue).
NL — Notochordal laminae (contents).
NA — Neural arch.
NC — Neural canal.
Nu — Nucleus.
P — Peritoneum, lining abd. cavity and covering intestine.
PG — Pigment granules of cord.
PC — Posterior aspect of cloaca.
SC — Spinal cord.
SM — Sphincter muscle of cloacal valve.
T — Integument.
TC — Tegumentary cells.
V — Vent or cloacal aperture.
Z — Supposed caudal sense organ.

1, 2, 3, 4, 5, etc. Caudal myocommata or muscular segments beginning with that which first abuts upon the cloaca.

Fig. 4 represents the caudal region magnified about ten diameters; it is in part diagrammatic, so as to include more features than could be really seen upon a single specimen without dissection. The Notochord (NN) is shown in its whole length, tapering gradually backward. Only the hinder end of the spinal cord (SC) is shown, but its course is indicated by the pigment granules (PG); which form a double row upon the sides of the median line throughout the whole length of the body excepting near the head (as shown by Müller and Owsjannikow) and near the posterior extremity; none of my specimens show them beyond the point where the muscular segments seem to cease, mainly about .000,5 from the tip of the cord; as shown by Owsjannikow, the granules are not generally opposite each other, or at regular intervals, in my specimens.*

Three spinal nerves are shown (CNe) of which the most anterior

*The cord is shown ending in a simple and free manner but I have several preparations which indicate some connection between its extremity and what appears to be a funnel-shaped canal leading from the surface at the point Z. I shall make this a matter of special investigation hereafter; Quatrefages describes the tip of the cord as enlarged, but is not certain of the constancy of that peculiarity.

The precise histology of this, as of all other parts, can only be determined and illustrated by very numerous preparations in different aspects and by much enlarged figures.

has a ventral as well as a dorsal division. (Compare Quatref., 14, pl. xii, fig. 1).

Excepting in very small specimens, the nerves can be seen only after carefully stripping off the integument, and the same is necessary in order to see the *caudal fin rays* (CFR).

CAUDAL FIN RAYS.—I am quite sure, from numerous observations upon small specimens from which the skin was removed, that the rays whose cut ends appear upon vertical section of the caudal region arise in a continuous series along the dorsal and ventral borders of the body, at least as far forward as the vent and run forward *almost horizontally*. Several *short* rays are represented by Müller (11, Taf. 1, Fig. 3 and p. 88) rising near the tip of the tail and inclining slightly forward. I am certain that these rays continue uninterrupted, and without branching over several segments; but I have not yet assured myself of their precise distribution, nor in what way they are accommodated in the narrower fin in front of the vent: I venture therefore to show only three rays above and below.

As represented by all authors, the myocommata (muscular segments) incline backward at their dorsal and ventral extremities so as to form a pretty regular curve the greatest convexity of which lies just opposite the notochord; the ventral moiety is the longer (excepting near the tip of the tail) and seems to extend farther back than the dorsal; but there seems to be no secondary dorsal and ventral curve as in ordinary fishes.

But there are dorsal and ventral longitudinal structures, which have been so variously described that, at present, I prefer to designate them merely as the dorsal ridge (DR) and abdominal ridge (AR) and their cavities as dorsal and abdominal segmented canal (DSC and ASC).

Whatever may be the precise nature and functions of this structure, however, it is in direct relation with the root of the fins and will form an element in the question of the position of the fins and the vent in respect to the median line. The dorsal ridge extends backward upon the median line almost to the final myocomma (this is shown in any lateral view, but I have not yet carried sections into that region). The abdominal ridge, in like manner, is median from the abdominal pore (not shown) backward upon the median line, to where the abdominal fin expands into the

caudal; here it decreases in size more rapidly than the dorsal ridge does at a corresponding point (although the interspaces are not shorter) and wholly disappears *from the lateral view* at the commencement of the cloacal region (its continuation will be seen in the sections) nor does it appear again in the post cloacal region, contrary to the figures of all authors.

THE CLOACAL REGION.—As first figured by Couch (4. p. 381), though not described and apparently not understood by him, and overlooked by all subsequent observers, the cloacal region is distinctly marked upon the left side by the failure of three or four myocommata to reach the level indicated by the corresponding myocommata of the right side.

In most of the specimens examined by me, the condition of things is represented in Fig. 4.*

The ventral extremity of the myocomma marked (1) is very slender and just fails to gain the level of the myocomma next in front; its successor (2) ceases at a still higher level and the next two (3 and 4) at higher and higher so that their ventral borders form an oblique outline from below, backward and upward; the greatest height of the space so uncovered being about .000,3 from the normal level, or about one-seventh of the depth of the body at that point; this line forms the antero-dorsal boundary of the cloacal region; the corresponding postero-dorsal boundary is formed by the antero-ventral border of the next myocomma (5) which reaches its normal level, as do its successors; the background of this space is formed by the mesial surface of the corresponding right myocommata, and its ventral outline is a pretty definite ridge (ClR), the nature of which will appear upon the sections.

The posterior fourth of the cloacal region is vacant and may be called the cloacal notch (ClN); (it is this which is liable to unnat-

* There is considerable discrepancy in the number of muscular segments (myocommata) both for the whole body and for separate regions; in the specimen figured (Fig. 4) I find that the ventral ends of four segments abut upon the cloaca, the most anterior very slightly, the fifth segment passes the cloaca and forms the dorsal and posterior boundary of the notch and there are sixteen more caudal segments, but in other specimens from Naples and also from Florida, there seem to be no more than fifteen post cloacal segments; there is reason to believe that the number varies with age but it is quite possible that the comparison of a large number from various localities may indicate a constant numerical difference serving to distinguish geographical varieties, and even, perhaps species; there is certainly a considerable difference in the height and thickness of the body, between the specimens from Naples and from Florida.

ural extension backward by the introduction of the bristle, as mentioned on page 282). The remaining three-fourths is usually occupied by the cloaca (Cl) excepting a slight interval between it and the background and ridge, which may be called the cloacal sinus (Cl S).

THE CLOACA.—In most small specimens and many of the larger ones from Naples, all which are strongly contracted by the spirit, the elongated triangular space (cloacal region) above described is empty; but the tegumentary cells may easily be traced over the rounded borders and also upon the deeper level of the background, from the surface of the fin, which is here connected *wholly with the right half of the body.*

But in other of the Naples specimens, and in all of those from the Florida coast, which, so far as this region is concerned, seem to be in a more nearly normal condition, the anterior three-fourths of the space presents a semi-cylindrical elevation of integument with a curved posterior outline. Its surface is continuous *dorsally* with the slightly overhanging margin of the myocommata; *posteriorly* with the contiguous surfaces of the cloacal notch; while the ventral surface is slightly separated from the underlying cloacal ridge, and extends across the middle line as will be shown in Fig. 5. It will be noted that this surface is smooth and presents no orifice whatever, and that we cannot therefore admit that the vent opens toward the left side of the *body;* this however by no means contradicts the statement that it opens to the left of the abdominal fin.

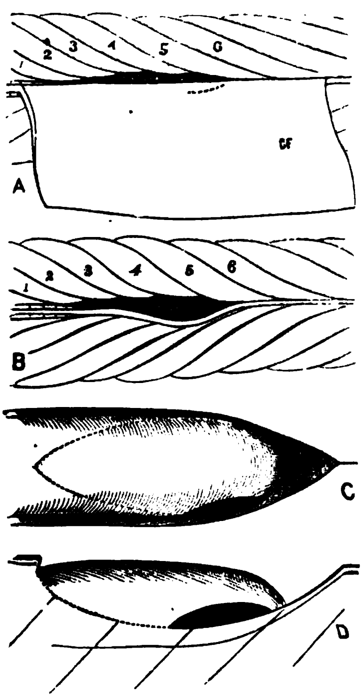


Fig. 5. Diagrammatic views of cloacal region from below (A, B and C) and from right side D; all more or less enlarged.

Fig. 5, A. View of the cloacal region from *below*, and still more enlarged than in Fig. 2. The caudal fin (CF) is turned over toward the right, but not distorted; its base is *upon the median line*, as seen at both ends of the section, and its exposed *border* therefore lies a little to the *left of that line;* the hidden border of course, to the right; upon each side of the anterior section is seen the abdominal ridge (AR) which is soon hidden upon the right, by the deflected fin, but continues backward upon the left to the cloaca where it seems to cease, but, in reality (as seen in B and in Fig. 4), is only narrowed and deflected dextrad of the median line so as to pass the cloacal region; the five cloacal myocommata are numbered 1–5, and the succeeding one 6.

It will be noted that owing to the fact that the base of the caudal fin preserves its true longitudinal course over the cloacal region, a little less than *one-half of the latter is visible;* the curved dotted line indicates the location of the vent; which is really dextrad of the median line, although practically, the outlet or pseudo-vent is a little *sinistrad* of that line, namely around the border of the base of the fin.

Fig. 5, B, is the same as A, excepting that the caudal fin is removed down to its attachment, so as to expose nearly the whole cloacal region; the attachment itself is deflected like the abdominal ridge, but remains visible around and behind the cloaca, where it again comes upon the median line; the cloacal notch is shown as a triangular black spot at the posterior extremity of the cloacal region, and the vent itself as a dark line upon the right posterior border, somewhat oblique, so as to be nearer the median line behind, but *not reaching it.*

In C, the cloacal region is still farther enlarged so as to show the relation of the parts to the median line; the dotted line indicates the limits of the exposed portion of the end of the intestine; the posterior extremity is seen to be rounded and the vent is a valvular aperture.

D shows the same from the right side, and diagrammatically; the border of the valve should be represented as slightly thickened and rounded.

I hope at some future time to give more detailed figures of this region, but these sufficiently indicate the morphological relations.

In figure 6 are given enlarged diagrammatic representations of transverse sections made at seven different points as indicated by the corresponding capital letters upon Fig. 4; all are as viewed from *behind*. As already stated, these figures indicate the results of a careful and prolonged comparison of several hundred sections made upon many specimens between the points A and G.

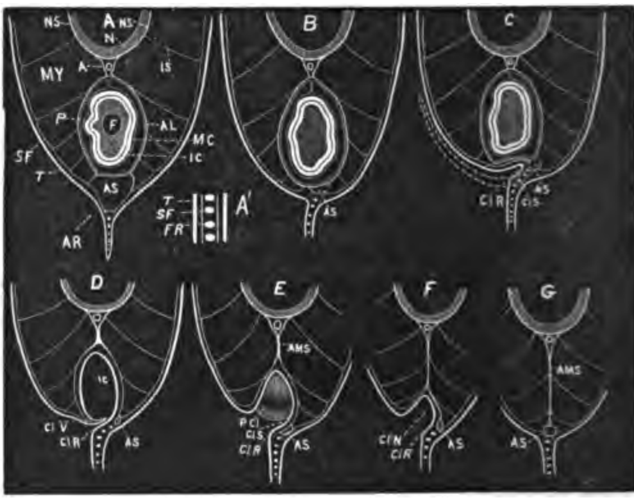


Fig. 6. Sections of cloacal region (ventral half of the body) as seen from behind. A is just in front of the cloaca and G just behind it; the others at intermediate points indicated by the lines in Fig. 4.

A is just in front of the cloacal region and G is just behind it; both of these are, therefore (or should be), symmetrical figures; all the others are more or less asymmetrical on account of the deflection of the abdominal ridge, and the attachment of the fin, and the location of the vent itself upon the right aspect of the cloaca.

The sections of course included the whole animal, but as the present paper concerns only the cloacal region, and several parts of the general anatomy of the dorsal region are in doubt, I prefer to show only what I am pretty certain of.

The lettering is uniform and explained elsewhere (p. 283). The general arrangement is best seen in A. The lower half only of the notochord (N) is shown, and its contents are omitted from

doubt of their exact nature; as in *Petromyzon*, etc., the notochord is surrounded by a sheath of connective tissue (N S) from which are given off the various *intermuscular septa* (I S) which separate the *myocommata* (My), and the *abdominal laminæ* (A L) which line the abdominal parietes. The *aorta* (A) lies between two laminæ; below the abdominal cavity the laminæ join the connective tissue walls of the *abdominal segmented canal* (AS) which constitutes the *abdominal ridge;* to the sides of the latter also, are joined the corresponding *subcutaneous fascia* (S F) which envelops the tegumentary surface of the muscular masses; to the lower border of the abdominal segmented canal also are attached the subcutaneous fasciæ of the caudal fin, which are only partly shown in the series A–G, but much enlarged in A′. The fin itself is wholly shown only in A, where its depth is slight; but its relative depth in the other sections may be judged by comparison with Fig. 2, which is magnified only half as many diameters.

In this too are shown the cut ends of the *caudal fin-rays* (C F R), already described; they seem to be usually oval in section, and sometimes composed of two lateral pieces; but their structure must be more minutely investigated.

Within the abdominal cavity is seen the cut end of the intestine, which, at A, contains a fæcal mass F. All authors state that the alimentary canal is ciliated throughout, but give no figures of either the cilia or the cells to which they are attached and leave us to suppose that no muscular or peritoneal coats exist.

As all these are points of minute anatomy which can be best determined upon living or fresh specimens, I hesitate to offer a description or figure of the parts, and must ask that both be regarded as provisional. As might be expected, so delicate a tissue as the peritoneum was rarely left uninjured in a section, but I think it exists in several specimens in the relation which is normal with vertebrates, and which is diagrammatically indicated in the figures (P), of course the parietal and visceral layers are really *in contact* with each other above (forming the mesentery M) and with the connective tissue and alimentary canal elsewhere.

The existence of an inner or mucous or epithelial coat is certain, also that, in the intestinal region, at least, it consists of columnar cells which give a striated aspect to the section; these cells are from .001 to .002 of an inch in length, and seem to be longer in the anterior than in the posterior part of the intestine,

giving a corresponding variation in the thickness of the mucous membrane (IC); traces of cilia appear in several of the sections, but I do not feel sufficiently sure of their uniform presence or their character to include them in the figure.

As said above, no muscular coat is assigned to *Amphioxus* by previous describers, nor have I seen any structure answering to it in the anterior part of the intestine, but in its posterior part and especially in the cloacal region, so constant is the appearance of a second coat outside of the mucous coat that I venture to insert it, provisionally, in the figure; very often it is somewhat separated from the mucous coat; its thickness is about the same but its structure is granular and not at all striated; prior to the investigation of this point upon fresh specimens, I would only suggest that perhaps the muscular coat is needed near the cloaca for the periodical expulsion of the fæces which are brought back by the constant action of the cilia, which may possibly exist only in the anterior (branchial) region of the alimentary canal.

B presents nearly the same appearances, but as it is a section just at the anterior angle of the cloacal region, it presents an indentation upon the left side of the base of the caudal fin, while the *abdominal segmented canal* (AS) is deeper in position and thrown to the right of the median line, like the fin attachment.

In C this change is more marked, the section being through the middle of the length of the cloaca, the AS is thrown far to the right and the base or attachment of the fin likewise, but the latter soon regains its normal position upon the median line, giving rise to two important features of this region the *ridge* and the *sinus*.

The *cloacal ridge* (CR) is the sudden angle formed by the vertical and median blade of the fin with its deflected basal part; it forms the outline shown as a single line in fig. 2 and appears in fig. 3 A as the sinister border of the fin.

The *cloacal sinus* (CS) is the space between the sinister surface of the deflected basal part of the fin and the ventral surface of the cloaca itself. The dotted line represents the fin in the condition already alluded to (p. 286) as thrown across and upward upon the left side so as to enclose and protect the cloacal sinus and the already concealed vent.

In D we have a section directly through the vent and exhibiting its peculiar features. As might be inferred from the other figures

(4 and 6 C) the integument may be traced from the left surface of the body upon the ventral surface and across the median line to a point where, in C, it becomes continuous with the integument of the fin-base, but in D it remains distinct and presently returns upon itself so as to form the mucous lining of the cloaca and the inner surface of the *cloacal valve* (ClV) which itself is merely the ventral wall of the cloaca, free upon its right border for the extent of the vent.

I have not represented the muscular and peritoneal coats in this section for I am not quite certain as to their points of commencement; neither a peculiar striated structure which appears in this part of the *valve* and which may be a special muscle for opening or closing the vent.

At E the section is made just behind the cloaca, so as to present its *posterior rounded surface* (PCl) which is continuous with the integument in all directions. The height of the cloacal cavity, which had somewhat decreased in D, is here little more than half what it was in A and the sub-aortic union of the abdominal laminæ here forms an *abdominal median septum* (AMS) the connections of which are as in all excepting A somewhat asymmetrical. The AS is rather larger and nearer the median line; the sinus and ridge occupy their usual places.

At F the section is through the vacant space, or *notch* (ClN) already described in fig. 2 and fig. 3, B, C, D, as a trihedral depression from the left side at the base of the fin; the median septum is still deeper, and the A S C nearer the median line.

In G, we find a return to the symmetrical arrangement of parts, but with the absence of the alimentary canal; the septum is median and its connections regular. In fact, in some respects it is easier to describe and study the sections in the reverse order beginning with G; which presents the simplest structure.

But although the arrangement above described may be required for protection of the cloacal outlet, especially during backward locomotion, yet it is quite possible that in order to avoid such circuitous exit for the fæces, the animal may flex its body strongly ventrad, to such an extent as to allow the deflected basal part of the fin to hang more directly from its attachment, and so expose the true vent at the moment of deflection; this must be determined by observation of living individuals. But this does not affect the morphological position of the vent upon the right of the median

line, but to the left of the abdominal fin, whose basal part is here deflected and attached wholly to the right half of the body.

I foresee one possible exception to the above interpretation of the morphological relations of the vent; upon the ground that the abdominal ridge and the fin are *normally median organs* like the similar dorsal structures, it may be urged that since the cloaca lies to the left of them, *it* is lateral in position, and to the left of the median line, and that perhaps the vent itself, if distortion were removed, might perhaps be regarded as median in its position, or nearly so.

This view would be strengthened by reference to the manner in which the *abdominal median septum* (AMS) maintains its connection with the abdominal segmented canal (ASC), as it is traced in the series of sections from G to A.

For a long time, while studying the sections under the microscope, I felt anxious to see that the median septum consisted of two lateral sheets which separated below so as to receive the alimentary canal; but there is no good evidence of this, any more than in the other fishes, where this septum consists of fibres interlaced in all directions, with no reference to a median division; and in F and E the septum seems to be deflected from the median line and to pass wholly to the right, leaving only a branch to go to the left.

But to this must be said—1. That the various septa form a continuous sheet of connective tissue, which is thicker in some places and thinner in others; that naturally the larger part of the median septum would retain its connection with the fin and the abdominal segmented canal which is evidently associated therewith: and, 2. That although the septum, and the abdominal segmented canal and the fin are all normally median organs, yet the latter two are *peripheral parts*, and hardly entitled to serve as criteria for determining the morphical position of a comparatively central or axial canal like the intestine; and although the septum consists of sclerous tissue, and might be ossified, and so become a part of the skeleton, to which all other organs are generally referred for their location, yet it must be remembered that the morphological value of the spinal axis arises not from its being of osseous or sclerous tissue, but from its primary appearance upon the line of the primitive furrow; in like manner the spinal cord and aorta and alimentary canal are all median and primary and

permanent organs; and their right to be so considered is not to be denied on account of the appearances presented by accessory prolongations of connective tissue, or by peripheral and transitory organs like the fins.*

RECAPITULATION.—1. The *abdominal folds* and the furrow between them extending from the oral aperture to the *abdominal pore* are periodical appearances, according to the condition of the reproductive organs.

2. The cloaca is usually about one-ninth (or .11) of the total length from the tip of the tail, and, including the four myocommata which abut upon it, there are 20–25 myocommata behind it; both the ratio and the number, however, are probably variable.

3. The caudal fin contains very long and delicate *anteverted* fin rays.

4. The caudal fin is continuous with the dorsal and abdominal fins; and the cloaca lies opposite the point where the greatest depth of the fin is acquired, passing from before backward.

5. On the left side three or four myocommata fail to reach the general level of the ventral border of the body and so expose the cloaca.

6. The *dorsal ridge* is always median and is visible to near the tip of the tail; but the abdominal ridge is deflected to the right of the cloaca, and does not reappear behind it, although it regains the median line.

7. The abdominal fin likewise loses its connection with the left myocommata and is attached wholly to the right side, but regains its median attachment behind the cloaca.

8. Nevertheless the *blade* of the fin always occupies the median line, and, at its junction with the deflected basal part, presents a distinct ridge, which forms the abdominal margin of the *pseudo-vent.*

9. The *true* (or morphological) *vent* is an oblique elongated opening upon the right side of the cloaca and considerably to the *right* of the median line.

10. But the basal part of the fin underlies this orifice and extends downwards to and slightly across the median line so as to bring

*For a brief discussion of the question as to the morphical values of parts and characters, see my paper,—Intermembral Homologies, Proc. Bot. Soc. Nat. Hist., 1871, vol. xiv.

the blade upon that line, and therefore, although the vent is to the left of the fin, yet,

11. Not only is the true vent invisible from either the right or left side, but the fæces in order wholly to leave the body, must pass to the left from the true vent and escape at a point which is really upon the left of the median line.

12. This complex protection of the vent, in connection with other appearances, suggests that backward progression of the animal is often resorted to.

But we must conclude, with Goodsir, that to "complete the history of the lancelet, an examination of it when alive in seawater must be undertaken. In this way only can certain points in its structure be explained and light be thrown on the economy of one of the most anomalous of the vertebrated animals."

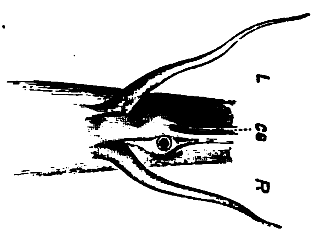


Fig. 7. Cloacal region of *Protopterus annectens*; natural size; drawn from a specimen in the Museum of Comp. Zoology, L the left side; R the right side; CG the caudal groove, a furrow upon the median line which divides the edge of the fin into two thin laminæ.

THE VENT IN PROTOPTERUS AND LEPIDOSIREN.—Müller's reference to the asymmetrical position of the vent in *Lepidosiren* (Protopterus) *annectens* has been quoted (page 276); Quatrefages follows Müller in comparing it with *Amphioxus*, but as shown in the above figure (which does not differ essentially from the figures and description of other authors),* the structural arrangements are quite unlike, for in *Lepidosiren* and *Protopterus* the vent is a distinct circular orifice wholly upon one side of the median line opening upon a sort of fusiform papilla or raised surface which, however, projects less from the surface of the body than the thick-

* Owen, Linn. Trans. xviii; Bischoff, Ann. Des. Sci. Nat. 3rd series, 14, Peters. Müller's Archiv für Anatomie, 1845; Vander Hoven, Handbook of Zoology, and Gunther's Catalogue of Fishes.

ened fin-base; this latter extends forward to between the roots of the skelea (hinder legs); for some distance behind the vent (in the specimen here figured) the thin border of the fin is in two laminæ with a groove between. The side of the fin-base opposite to the vent projects somewhat like the vent papilla, and all authors agree that the vent opens sometimes upon one and sometimes upon the other side. Without sections of the body at this region and the study of the embryonic condition of the parts one cannot be sure of what is their morphological relation, but they appear as if the vent, a normally median organ, opened itself upon one or the other side of the fin-base and that the two mutually crowded each other a little from the median line; perhaps the blade of the fin is deeper in the young individuals.

IN CERATODUS.—In a large specimen of *Ceratodus Forsteri* at the Museum of Comparative Zoology the fin ceases considerably behind the vent, and this is apparently a median opening, although slightly asymmetrical in form, perhaps on account of distortion in the spirit. Günther makes no mention of a peculiarity of this region.

THE VENT IN MYZONTES (MARSIPOBRANCHII).—Whatever may be their precise zoological relationship,* there is no doubt that the *Myzontes* are the group of vertebrates next above *Amphioxus*, and it is therefore desirable to ascertain the character of the vent in the three genera now constituting the group.

In *Myxine glutinosa* the vent is a longitudinal median slit between what might at first seem to be the divided moities of an abdominal fin. I have not as yet made the sections which would probably decide the matter, but am inclined to think that the true fin lies wholly behind the vent, and the slight cutaneous fold which lies in front of and behind it is not in the strictest sense a fin like that which exists in *Amphioxus*.

* Of late years the opinion has gained ground that the peculiarities of *Amphioxus* are such as to entitle it to the rank of a sub-class or class or even sub-kingdom; with this, however, I have never sympathized. I hesitate to express a contrary opinion without more extensive knowledge than I now possess, but it may not be improper to state that last summer (at the Anderson school of Nat. Hist. Penikese Id., Aug., 1873), after a lecture in which I contrasted diagrammatic views of the branchial apparatus in *Amphioxus*, *Myxine*, *Bdellostoma* and *Petromyzon*, Prof. Agassiz announced his belief that these four genera would prove to be the representatives of four groups which he would regard as orders of the class *Myzontes* (or marsipobranchs). This opinion might and will hereafter, be confirmed by many other considerations which I now refrain from presenting.

In *Bdellostoma polytrema* the body is deeper in front of than behind the vent, which is thus caused to look backward as well as ventrad, between two folds which seem to be equal or if unequal, not so in any uniform manner; all the specimens examined by me, (from the Mus. Comp. Zool.) are in poor condition.

IN PETROMYZON.—It so happened that the three representatives of this genus first examined by me were a large *P. Americanus* ♀, and two small specimens from Cayuga Lake of a species which I do not yet regard as satisfactorily determined; the first named presented a sort of notch in the right half of the body just at the vent, which gave the latter a decided *sinister* aspect; the two smaller specimens were a ♀ and ♂; and in one the vent looked to the right, in the other to the left; and I imagined this peculiarity might relate to convenience in copulation; but of seventeen specimens of *P. Americanus* since examined, no such condition of things exists; a much larger number of specimens must be examined before any generalization can be made. I am inclined to think, however, that the very early larvæ of the *Myzontes* may present an *Amphioxus*-like structure of the cloaca.

THE VENT IN THE LARVÆ OF RANA PIPIENS.—An examination of fifteen larvæ of *Rana pipiens*, taken in the same stream in June, 1873, showed that in every case there was a decided asymmetry in the cloacal region. The median caudal fin is continuous from the tip of the tail to the abdominal integument. In the specimens with small skelea (hind-legs) the connection between the abdomi-

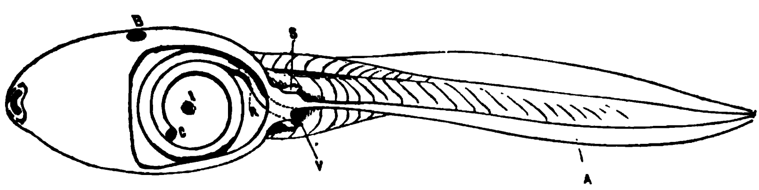


Fig. 8. A larva of *Rana pipiens*, partly dissected, seen from below; B, the persistent left branchial orifice; most of the intestinal coil has been removed, I being the cut end of the pyloric portion, and C the cut end of the last coil; R the *rectum* lying close against the left side of the abdomen, before crossing to the median line to open at V the vent between the two moieties of the fin (A), of which the right is much thinner; S, the left skelos or hind leg.

nal skin and the fin proper is a broad fold, which becomes reduced, apparently by absorption, as the skelea increase, until in those farthest advanced it forms a mere ridge upon the middle line.

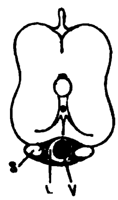


Fig. 9. A transverse section of the root of the tail of the same larva of *Rana pipiens* made in a plane indicated by the line S in fig. 8. S, the cut end of the left skelos; L, the thicker left moiety of the fin which is continuous with the caudal fin; the thinner right moiety ceasing at a point just behind the section.

Now the vent seems to divide this into two laminæ of which the left is always the larger and thicker, while that upon the right of the orifice is thinner and in the specimens with largest skelea, has nearly disappeared; the vent must therefore be described as wholly or in part on the *right* of the median fin in these larvæ.

But the fact that the vent is to the right of the caudal fin, and that the latter is not as is usual among vertebrates, wholly interrupted by it, does not necessarily enable us to say that the vent is *dextrad of the median line;* on the contrary, I am inclined to think that the vent is really upon the median line, in the larva as in the adult, and that the laminæ of the anal fin are divaricated unequally according to their different thickness, giving the apparently lateral position of the opening as already described.

We ought perhaps to discriminate between the *real vent* as it exists in *both* stages of growth and the orifice of the short tube* between the deciduous laminæ, which orifice certainly looks toward the right.

It is obvious that a more extended examination should be made of the larvæ of different Batrachians; and the purpose of this paper is mainly to call attention to a peculiarity which, so far as I am aware, has not before been observed.

The condition of things is more like that of *Bdellostoma* than *Amphioxus;* and a curious contrast exists, from the fact that while

* Alluded to by Owen (C. A. V., vol. i, 628) as the "tegumentary and transitory cloacal canal at the fore-part of the subcaudal fin."

the latter form gains a caudal prolongation beyond the vent, *Rana* loses the tail in the course of development; and the adult cloacal aspect is not unlike that figured by Kowalewsky in the *Amphioxus* of sixteen hours.

WEIGHTS AND MEASUREMENTS (IN GRAMS AND MILLIMETERS) OF LARVÆ OF RANA PIPIENS, MADE WHILE SPECIMENS WERE FRESH, JUNE 16, 1873.

No.	Weight.	Length of Skelea (hind legs).	Body (muzzle to vent).	Tail (from vent).	Total length.	Alimentary canal from mouth to bight of intestine.	From bight to vent.	Total.
1	,013.	.003,5	.041,	.076,	.117,			
2	,013.	.004,	.041,	.074,	.115,			
3	,015.	.004,	.037,	.076,	.113,	,413,	,350,	.763,
4	,016.	.004,	.042,	.076,	.118,	,500,	,365.	.865,
5	,015.	.005,	.042,	.078,	.120.			
6	,013.	.006,	.041,	.076,	.117,			
7	,014.	.008,	.041,	.080,	.121,			
8	,020.	.012,	.046,	.086,	.132,			
9	,019.	.013,	.043,	.087,	.130,	,465,	,380,	.845,
10	,022.	.037,	.045,	.097,	.142,			
11	,021.	.038,	.048,	.098,	.146,			
12	,020.	.040,	.046,	.098,	.144,			
13	,026.	.042,	.047,	.089,	.136,	,760,	,513,	1.273,
14	,028.	.046,	.045,	.100,	.145,			
15	,025.	.051,	.046,	.091,	.137,			

Having arranged the specimens according to the increase in length of the skelea, we see:

1. A general increase in the weight and total length; and, with the four measurements given, in the length of the alimentary canal; but none of these increments are constant.

2. The skelea of 10 are nearly three times as long as those of 9; but the increments of length and weight of body are gradual.

3. The comparison of 13 with 9 indicates that the shortening of the alimentary canal, which is said to occur at a later stage,* has not yet commenced.

* Owen, C. A. V., i, 624.

ADDENDUM.—Through the kindness of Prof. Theodore Gill I have to-day (April 29, 1874) received a copy of Stieda's "Studien uber Amphioxus lanceolatus," read before l'Academie imp. des Sciences de St. Petersbourg, Sept. 5, 1872, and published in March, 1873; its presentation and publication thus antedating those of my paper by about a year.*

Although the foregoing paper was already in type, room was kindly made for the present note respecting Stieda's paper. It is chiefly histological, with historical and critical remarks; embracing only seventy pages, and yet touching upon the whole structure it is necessarily very brief in many respects.

Of the twenty-five figures, seven are magnified sections of the entire animal, at the following points: in front of the mouth, through the mouth, through the anterior part of the respiratory cavity, through its posterior part, at the vent and behind the vent. A review of most of the points of general structure must be deferred to another occasion; in some respects my observations confirm his, in others I am not prepared to make a positive assertion, but in a few I am sure he is incorrect. The only reference to the position of the vent is on page 5:—"Hinter dem Porus abdominalis, im Bereich der eigentlichen Afterflosse, befindet sich, an der linken Seite, die nur kleine afteröffnung." (Behind the abdominal pore, in the region (line ?) of the true anal fin, lies the very small anal opening).

I give a copy of the lower half of his figure representing the section at the vent; it is *reversed* for convenience of comparison with my own, since his is as if viewed from in front, while all mine are as if viewed from behind.

With regard to the minute structure of the intestine which he describes as presenting in addition to the peritoneum, an outer thinner coat, a middle or thicker coat, and an inner or epithelial layer which, at the vent, gradually merges into the ordinary cuticle, Prof. Stieda's reputation as an histologist deters me from positive counterstatement at this time; but as to the morphological relations of parts to each other and to the middle line, I am obliged

*Foreign scientists will hardly be able to believe that a memoir upon so interesting a subject, and in a periodical which doubtless is at once received in every university library of Europe, should so long be unknown to a worker in the same field here and even then be first learned of through the "scientific record" of a popular magazine, "Harpers' Monthly;" but my American brethren will understand the case, for they know that, excepting only at Boston, New York, Philadelphia and Washington, they are always liable to do over what has been already done a year or more before, and to rediscover things which are already familiar.

to differ with him, and trust that he will, upon reception of my paper, reëxamine this point, as I shall this and others in the light of his researches.

I am enabled to offer the following additions to the bibliography from the complete list of works at the end of Stieda's paper.

Costa, Cenni zoologici ossia descrizione sommaria di talune specie nuove di animali. Napoli, 1834.

Notice sur le Branchiostome, Comptes rendus T., xiii, p. 873, 1841.

Notice sur le Branchiostome, L'Institut, I, Sect. ix, No. 407, p. 345, 1841.

Frammenti di Anatomia comparata, Fascic. I, Sporia e Notomia del Branchiostomum lubricum. Napoli, 1843 fol.

Ueber Branchiostoma, Isis, p. 708, 1846.

Gervais et van Beneden, Zoologie médicale, T. I, p. 287, 1859.

Goodsir, An. Nat. Hist. vii, p. 346.

Hoven, Verzameling van berigten over Amphioxus l. Tijdschrift voor natürl. Geschiedenis, D. viii (2 Afd.), p. 73, 1841.

Harting, Leerboek van de Gronbeginselen der Dierkunde, II, D. I. Afd. 4, Visschen, Tiel, H. E. A. Campagne, 1865.

Huxley, Examination of the Corpuscles of the Blood of Amphioxus, Trans. Brit. Assoc., p. 95, 1847.

"KoBaNeBCKIN, NCTOpIH paЗNTIH," Amphioxus l., 1865.

Lindsay, On Amphioxus l. An. Nat. Hist., 2 Ser., vol. 23, p. 339, 1857.

Leuckart und Pagenstecher, Untersuch, ueber nied Seethiere Amphioxus l. Müller's Archiv, 1858, p. 568.

Martino, Sull' anatomia del Branchiostoma l. Giornale dell Instituto Lombard, T. vii, p. 172, 95, Milano, 1846.

Wilh. Müller, Beobacht, des pathol. Instituts zu Jena, Spec. Th., Reike I. Ueber den Bau der Chorda dorsalis. In der Jenaischen Zeitschrift f. Med. w. Naturw. Bd. vi, p. 287, 1867.

Reichert, zur Anat. des Branchiostoma l, Reichert's Archiv, 1870, p. 755.

Fig. 10 (copied from Stieda, Taf. 2, fig. 9; reversed, and cut light on a dark ground.) This is to be compared with my figure D, fig. 6.

On the Composition of the Carpus in Dogs. By B. G. Wilder, of Ithaca, N. Y.

In a paper "On the composition of the carpus of the dog,"* Prof. Flower describes and figures the right carpus of a dog about six weeks old in which the "so-called *scapho-lunar* bone, though well ossified consists not only of a perfectly distinct *scaphoid* and *lunar* but also of a third piece, evidently corresponding to the *os centrale* of the typical carpus," p. 64; and regards this as "proving that in the dog at least neither the *radiale* (scaphoid), *intermedium* (lunar), nor the *centrale* are suppressed, but they are all developed independently and afterwards coalesce to form the so-called scapho-lunar bone."

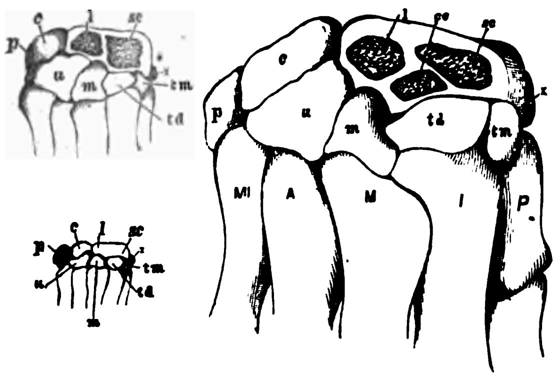


Fig. 1. The right carpus of an Asiatic lion, seven months old (largest figure), of a shepherd pup, and of a new-born English black and tan rat terrier (smallest figure); all are drawn from above and of natural size. The lettering is uniform. P. Pollex; I, Index; M, Medius; A, Annularis; Mi, Minimus. *p*, *pisiform*; *x*, *radial sesamoid*, a cartilaginous nodule attached to the radial border of the scaphoid; *sc*, scaphoid or *radiale*; *l*, lunar or intermedium; *ce*, *centrale*; *c*, cuneiform or *ulnare*; *tm*, trapezium; *td*, trapezoid; *m*, magnum; *u*, unciform.

Wishing to confirm the above statements upon other specimens I examined the parts in question upon two young dogs and a young Asiatic lion, carefully removing thin slices of the cartilaginous *carpi*; the figures show that:

1. In this lion seven months old, the *scapho-lunar* is a single cartilage, containing three centres of ossification, which undoubtedly

* Read at the British Association Aug. 7, 1871, and published in the Journal of Anatomy and Physiology, Nov., 1871, page 62.

correspond to the three elements, *scaphoid*, *lunar* and *centrale* and which would probably, at a later age, coalesce into one bone.

2. In the shepherd pup (age unknown) the single scapho-lunar cartilage contains but two ossifications; the radial one, however, is so large as to allow the supposition that it represents the already coalesced *scaphoid* and *centrale*.

3. In the new-born terrier, the cartilage presents no trace of ossific deposit, though sections were made in all directions; it is moreover single and undivided, as in the other cases, but as it articulates with the *cuneiform* and *unciform* on the one side, with the *trapezium* on the other, and with the *magnum* and *trapezoid* by its distal border, it must be held to represent the *scapho-lunar* just as much as do the partly ossified cartilages in the other two cases.

A similar appearance is presented in a fœtal gray wolf the mother of which died four days before the expected time of birth, and in a young red fox, whose eyes were just opening.

From the above facts we may conclude that:

1. The carpal element *centrale* which Gegenbaur holds to enter into the composition of the typical carpus, but which he found distinct only in *Quadrumana* and in some *Rodentia* and *Insectivora*,* exists as a separate centre of ossification in a young lion, and is probably represented in the young shepherd dog and the terrier; as in the young dog described by Flower.

2. But in the three cases described by me the cartilages of these three elements are probably *connate*, and the osseous formations *coalesce;* while in Flower's example there seems to have been neither connascence nor coalescence of either cartilage or bone; for even if we suppose that in that case a single cartilage afterward divided, yet it is certain that no such change occurs in the lion; and since the shepherd pup presents only two ossifications, we must either conclude, as above that a coalescence of *centrale* with *scaphoid* has occurred, or that in this kind of dog the *centrale* is wanting.

3. It is easier to imagine that the *Carnivora* may vary among themselves and that the dogs in particular, which in so many other respects present striking differences, may vary in regard to the manner of formation of carpal elements and even perhaps as to their existence.

4. It is evident that any generalization respecting dogs should specify the breed, age and sex.

* Carpus und Tarsus, p. 50.

PRESENT ASPECT OF THE QUESTION OF INTERMEMBRAL HOMOLOGIES. By B. G. WILDER, of Ithaca, N. Y.

ATTENTION is called to the apparent unconsciousness of English and Continental anatomists that there exists, chiefly in the United States, an opinion respecting the homology of the anterior and posterior limbs, totally at variance with their own; and it is suggested that if each party will yield a part of its present position, a reconciliation may be effected. I hope, by means of embryology and the study of *Amphioxus* to demonstrate the existence of a true "meketropy" (antero-posterior symmetry) within the vertebrate branch. I hold that if the same methods of comparison and of deduction which are employed in studying the limbs of different animals are used in comparing the anterior and posterior limbs of the same animal, there can be no escape from the conclusion that the anterior digit (thumb) is the true homologue of the posterior dactyl (little toe); and that the little finger is in like manner the true homologue of the great toe. To this opinion are now inclined the following anatomists: Wyman, Agassiz, Dana, Coues, Foltz, and the writer; all others now living, and those who have written on the subject since 1774, hold the contrary opinion.*

VARIATION IN THE CONDITION OF THE EXTERNAL SENSE ORGANS IN FŒTAL PIGS OF THE SAME LITTER. By BURT G. WILDER, of Ithaca, N. Y.

IN comparing fœtal mammals of unknown age, it is natural to estimate their relative age, partly according to the degree of closure of the lids, and the direction of the pinnæ; since it is known that the former are at first mere folds above and below the uncovered balls, which are gradually covered by them; and that the pinnæ are first formed as little triangular folds behind the meatus, which at first project directly forward, and then, as

*A historical sketch of the question, with a full bibliography is given in a paper lately published by me, Intermembral Homologies; Proc. Bost. Soc. Nat. Hist., 1871.

they increase in size, gradually rise to the erect position, and only later are retroverted upon the neck.

While forming a collection of fœtal pigs at the large *abattoir* of J. P. Squiers in East Cambridge, Mass., during the summer of 1872, I compared the individuals of the same litter, carefully avoiding any artificial displacement of the parts.

Fig. 1. A. Head and series of pinnae from fœtal pigs (Nos. 296 to 300, M. C. Z.) of the same litter.
B. Head and series of eyes from fœtal pigs of the same litter (Nos. 303 to 309).

In the five pigs of the same litter * having an average length from vertex to anus of ·067, mm. and an average weight of ,017·5 grams, the direction of the pinna ranges from a slight but decided *anteversion*, to an almost complete *retroversion*. Figure 1, A.

In the seven pigs of another litter † averaging ·040, in length, the lids range from folds covering slightly the upper and lower margins of the ball, to complete closure. The sizes and degrees of closure do not exactly coincide. It would be interesting in both these cases to know the relative position of the individuals in the mother's uterine cornua; but these facts indicate the need of far more extended comparisons than have been made.

I have also observed some striking changes in the form of the nostril in fœtal pigs; it is in its earliest condition a notch, whose lower margins then come together forming a hole; this elongates laterally and is indented above so as to become more and more crescentic; but at or before birth the circular form is regained and retained through life; illustrations of these changes will be presented upon another occasion.

* Marked 296 to 300 on the Catalogue of Neurology and Embryology of Domesticated Animals at the Museum of Comparative Zoology, Cambridge, Mass.

† Marked 303 to 309 in the same catalogue.

THE PECTORAL MUSCLES OF MAMMALIA. By BURT G. WILDER, of Ithaca, N. Y.

THE following is a provisional abstract of results based upon the dissection of the pectoral group of muscles of twenty-two genera of mammals, representing all of the usually recognized orders, excepting the *Solipedia*, *Hyracoidea*, *Cetacea* and *Sirenia*.

Before publishing in detail and with figures from the drawings* which I have made of all the dissections, I wish to examine several other genera (particularly *Lutra*, *Phoca*, *Delphinus*) and also other individuals or species of the species and genera here enumerated.

Homo,	Man.
Troglodytes,	Chimpanzee.
Pithecus,	Orang.
Macacus,	Monkey.
Galago,	Lemur.
Felis catus,	Cat.
Felis leo,	Lion.
Canis occidentalis,	Gray wolf.
Canis familiaris (see next paper),	Dog.
Ursus,	Bear.
Procyon,	Raccoon.
Putorius,	Weasel.
Mephitis,	Skunk.
Scalops,	Mole.
Condylura,	Star-nosed mole.
Pteropus,	Bat.
Bradypus,	Sloth.
Myrmecophaga,	Ant-eater.
Cyclothurus,	Little ant-eater.
Dasypus,	Armadillo.
Mus,	Rat.
Arctomys,	Woodchuck.
Bos,	Cow.
Cervus,	Deer.

* These drawings were shown at the meeting.

The investigation began in an effort to reconcile conflicting statements respecting the existence of the *Pectoralis minor* in the cat and some other Mammalia. Strauss-Durckheim denies its presence in the cat; and Cuvier and Meckel in some other *carnivora;* while others (Haughton), mention its presence without comment.

In nearly all Mammalia the main pectoral mass is naturally separable into an outer and an inner layer; these are respectively homologous with the *Pectoralis major* and *P. minor* of man; for convenience and in order to avoid the ascription of less constant attributes than relative position, they may be called respectively *ectopectoralis* and *entopectoralis;* as the buttock muscles are now called *ecto-*, *meso-* and *ento-glutæus.*

The usual origin of the *ectopectoralis* is the middle line of the sternum, and a median raphé anterior to it; its insertion is into the outer tuberosity of the humerus, and distad therefrom upon the same bone; the usual origin of the *entopectoralis* is from the anterior angles of the costal cartilages and sternum, and from the contiguous borders of these parts; its insertion is upon the outer humeral tuberosity and outer margin of the bicipital groove, covered more or less by the insertion of the *ectopectoral.* But there is nearly always a small but distinct tendon which is attached to the *coracoid process* or to the tubercle representing it in many quadrupeds; this is interesting in view of the fact that in *Quadrumana* often, and in man usually (but by no means so generally as is supposed), the entire attachment upon one or both sides is upon the coracoid process.

This coracoid insertion is perfectly distinct in all the *Canidæ* and *Felidæ* dissected by me; but Strauss-Durckheim, not recognizing the *entopectoral* as such on account of its great size, describes the tendon of the *sterno-trochiterien* in the cat (which he regarded as a dismemberment of the *P. major*, as sending a slip to the *supra spinatus;* teleologically it might as well be so, but morphologically there is every reason for its attachment to the rudimentary coracoid. The above, by the way, is the only error in description which I have found in that admirable monograph; but errors of homological interpretation are by no means uncommon.

The *ectopectoralis* tends to separate, especially anteriorly, into superimposed laminæ; while the *entopectoralis* tends to form fasci-

culi, corresponding to the number of costo-sternal articulations involved in its origin.

The *ectopectoralis* has generally an outward direction, and acts therefore as an *adductor humeri;* the *entopectoralis* has an oblique direction from within, forward and outward, and acts chiefly as a *retractor omou* (retractor of the shoulder). The *entopectoralis* is generally much the larger, the exceptions being man, the higher quadrumana, the bear, the skunk and the bat.

In addition to the main pectoral mass, there are generally found one, two or more smaller muscular elements, whose relations are variable with the thorax and armus, with the main pectoral mass, and with certain other muscles (*latissimus dorsi, dermo humeralis, rectus abdominus* and *obliquus externus.* It is probable that these are differentiated portions of the main pectoral mass, but a more extended comparison is needed.

There is need of more accuracy in the dissection, delineation and description of muscles; since at present there is great confusion respecting the nature of true muscular integers, and the basis of muscular homologies; as a provisional opinion, it may be stated that size, form and function are much less reliable than origin, relative position and insertion, and that origin is the most reliable basis for muscular homology.

The most profitable work will be the careful comparison of *nearly allied species and genera.* At present, so little are we agreed upon the basis of arrangement that each new "myology" is in great part useless in the present and a burden upon the future; in fact, we should do well to avoid publication of dissections made of a single specimen of a species, and a single species of a genus; and of all dissections by *beginners.* My own experience has proved the risk of fallacies resulting from the too sparing or too persistent use of the knife, and the overlooking of points which may have no teleological importance, but great morphological significance.

VARIATION IN THE PECTORAL MUSCLES OF DOMESTIC DOGS. By BURT G. WILDER, of Ithaca, N. Y.

ABSTRACT.

I HAVE made drawings* of my own dissections of the pectoral muscles in nine breeds of domestic dogs (*Canis familiaris*), as follows: English terrier, skye terrier, spaniel, greyhound, spitz or Pomeranian, setter, Newfoundland, St. Bernard and shepherd. Like that upon the brains of dogs, this investigation was begun in order to ascertain whether among our domestic dogs there exist internal and structural differences comparable with those of habit and external appearance, which are greater than would be held to characterize distinct species of wild animals.†

Deferring publication in full until a greater number of breeds have been examined,‡ and until the general homology of the *pectorales* is determined, I would say here that so far there has been great uniformity in the main pectoral muscles, *ectopectoral* and *entopectoral;* certainly no such differences as might be inferred from the external appearances of the breeds. Among the minor outlying members of the group referred to in the preceding paper, there is some variation, but usually not more than might be attributed to mere individual peculiarity.

The stomachs and cæca of these and several other dogs are preserved, inflated, in either Ithaca or Cambridge. I hope at some time to present superposed outlines of these for exact comparison.

ON THE EMBRYOLOGY OF TEREBRATULINA. By EDW. S. MORSE, of Salem, Mass.

ABSTRACT.

AT the last meeting of the Association I presented a few observations on the embryology of Terebratulina, in which the segmented character of the embryo and its free swimming state were noticed.

* These were shown at the meeting.

† Yet as remarked on page 242, even the child recognizes them all as *dogs*.

‡ A Chinese dog and a Mexican (Chihuahua) dog are among the specimens awaiting dissection.

Lacaze-Duthier had noticed a similar stage in Thecidium, but nothing had been done to close the wide gap existing between this free annulated stage and the early stages in which the adult characters are conspicuous, as shown in my paper on the early stages of Terebratulina.

This spring I have had the good fortune to make plain the history of the development of the dorsal and ventral areas, the peduncular attachment, and the relations the different parts of the mature animal bear to the embryonic segments, as well as to present some new features in the early stages of the species. (As my paper has since been published in full, with illustrations in the Memoirs of the Boston Soc. Nat. Hist., vol. ii, p. 249, I need only give here a summary of the stages presented in the development of the embryo.)

The development of the embryo presents a series of well defined stages. In the first stage the embryo becomes widened at one end. The segments are barely indicated, the posterior end is the widest, the anterior portion is ornamented with a conspicuous tuft of long cilia, so peculiar to the embryos of many worms. The embryo is also clothed with vibratile cilia, and in this condition slowly moves along the bottom of the dish without rising from it, or remains quiet. In the second well marked stage the embryo is divided into two prominent segments; these expand and contract upon each other slightly, and the cephalic segment has the power of partially bending from side to side. In this stage the embryo is most active, swimming rapidly in every direction and turning abruptly about. The œsophagus also becomes dimly defined. In the third stage the peduncular segment is developed and projects from the posterior portion of what can now be called the thoracic segment. At this stage the embryo either remains immovable upon the bottom of the dish or slowly moves about. In two cases delicately barbed setæ to the number of thirty-five projected directly backward from the peduncular segment. In the fourth stage the embryo becomes attached by means of its peduncular segment. The embryo is still clothed with cilia, though the long pencil of cilia has disappeared. The head is closely drawn to the thoracic segment, which becomes wider in transverse diameter, so as nearly to hide the peduncle. In the fifth stage the thoracic ring commences to fold, or turn upward upon opposite surfaces of its circumference, so as gradually to enclose the head; one fold being

made slightly in advance of the other represents the larger or ventral valve. In this stage appear clusters of barbed and deciduous setæ upon the anterior margin, and in a later portion of this stage the first hardened areas of the dorsal and ventral plates make their appearance, and the cirri appear as blunted papillæ about the mouth. In the sixth stage the shell becomes rounded, the peculiar scaled structure makes its appearance, and the formation of tubules perforating the shell and permanent setæ takes place.

On the Genitalia of Brachiopoda. By E. S. Morse, of Salem, Mass.

ABSTARCT.

A careful study of Terebratulina, made this summer, shows the sexes to be distinct, while some specimens revealed the vascular sinuses filled with eggs, and even where the eggs had escaped by dehiscence the scars could be seen; in others the sinuses showed no traces of eggs, but on the contrary were filled with a creamy mass, slightly granulated, the borders of these masses being highly ciliated and when crushed or separated under the compressor, bunches of spermatozoa and single ones were revealed. This probably represents the oviparous mass of Hancock. In several females examined the eggs were attached in clusters to the genital band, and in such masses and so close to the segmental organ that the accessory vesicle of Huxley was obscured by them. The masses of spermaries adhering to the genital band, and floating freely in the perivisceral cavity, presented some curious features. They assumed the shape of long filiform masses, attached by common centres to the genital band, and surrounded by an almost imperceptible cellular mass.

The threads widened gradually to their distal extremities where they ended bluntly, and were capped with a few large brownish cells.

The spermatozoa were thickly clustered in blunt fusiform masses at the extremities of the threads forming a sort of brush.

The same brownish granules appeared in the sinuses, and likewise tipped the clusters therein contained, only these clusters were not supported on long threads, as in those which sprang from the genital band in the perivisceral cavity. The glandular portion of the segmental organ in the male appeared much darker than in the female.

From examinations of Lingula, Discina and Rhynchonella, I believe the sexes will be found separate in all Brachiopods.

(As I have treated this subject more fully in a paper entitled Systematic position of the Brachiopods, Proceedings Boston Soc. Nat. Hist., vol. xv, p. 346, the reader is referred to that paper).

On the Rate of Increase of the Human Race. By Chas. Whittlesey, of Cleveland, Ohio.

If we could determine the number of people existing upon the earth at several periods of time, widely asunder, the general rate or ratio of increase could be obtained. This would constitute a mathematical series, diminishing backwards, till it would terminate at the period of man's origin, on the supposition that there was but one pair of progenitors.

This was the object I proposed to myself in this investigation. It is not an uncommon occurrence, that investigations made to sustain a theory lead to results quite different from our anticipations. Instead of finding a rapid and regular increase of population throughout the earth, the indications are that from the commencement of the Christian era, to the beginning of the present century the rate of increase was very small. This conclusion is not capable of a complete demonstration, because the ancient enumerations are not now to be found. I have not discovered a thorough census of any nation prior to the year 1800.

Any government, having an organization sufficient to raise a permanent army and enforce a general tax, must have had record evidence of the number of its people, and of the amount of their property. There are numerous references to such enumerations among the old monarchies, but the statistics which they collected are nearly all lost. In the Grecian States, as early as 600 B.C., it was the practice to take a regular census. From at least 500 B.C., the same was done in Italy and the Roman Empire as often as once in five years. Only a few of the items, however, have come down to us.

The earliest record of a census which we have is that of the males who were able to bear arms under Moses, when the Israelites came out of Egypt, 1491 B.C., and this was not a full enumeration of the people, but only of the military force. The two subsequent numberings were a little more full, but the entire population is nowhere given, and is obtained only by deduction, in a mode I will discuss under the head of the Jewish tribes.

There are numerous instances in history, where the number of persons inhabiting a city at different times is given. The strength of armies is more frequently found on record, from which the strength of a nation may be deduced. Where two countries are at war a long time, with nearly equal forces and success, it may be inferred that their resources and numbers are nearly equal.

The revenues collected from a people are indicative of their numbers. With all these considerations in view, I have endeavored to arrive at the population of this planet near the time of Christ, and thus make a comparison between that period and the beginning of the present century. To facilitate the comparison, I shall give details of what I have gathered in reference to several ancient nations, although a portion of the details have not a direct bearing upon the question, *when man first appeared upon the earth.*

The developments of the past ten years throw the epoch of the cave dwellers back, to the closing out of the glacial period. Anything which may help to fix this period, in a historical or chronological form, is worthy of attention.

The census of a single people, no matter how complete, or how much time it embraces, forms only one item in the calculation; for all nations have their rise, progress, culmination and decline. It requires a consolidation of all people, through long periods of time, to throw much light on the problem of the antiquity of man.

Before I close, I will present a recapitulation of the information within my reach, the tendency of which is, like that of the cave relics; to put the origin of man very far back in the history of the earth.

ITALY AND THE ROMAN EMPÍRE.

Geographical Italy now supports about twenty-four millions of people. Of the number at a period near the Christian era, we can do little more than conjecture. The propensity of mankind to congregate in towns and cities is the same in all ages, and thus the proportion of the rural to the city population, in civilized countries, must be nearly constant. There is reputed to have been three hundred and twenty towns and cities, in the Italian peninsula in the days of Augustus Cæsar, a time when that country was in its most prosperous condition.

In the United States about *twelve per cent.* of the population live in towns of ten thousand and upwards. In England and Wales there were, in 1851, five hundred and eighty cities, the average population of which was 15,500, twenty-five of which were above 52,000. As this represents a dense manufacturing country, embracing the capital of vast possessions abroad; the urban population is exceptionally large. In France (1855) there were thirty-two cities exceeding 40,000 people. These contained *nine per cent.* of the empire. Prussia had fifteen cities larger than 32,000, which represented *seven per cent.* of her population.

If the 320 towns and cities of Italy had an average of 10,000, they embraced 3,200,000. The city of Rome in the days of Claudius is estimated by Hume at 1,200,000, and by Gibbon not less than 1,000,000, or nearly one-third of 3,200,000. If we regard this as representing only *seven per cent.* of the rural population we have 22,400,000 people, in geographical Italy at that time.

About 200 years before Christ, the city of Carthage, according to Strabo, while she was a rival of Rome, fighting under Hannibal, contained 700,000 souls. Carthagena, in Spain, was not long after regarded as nearly the equal of Rome.

In the campaigns in Spain, before the defeat of the Carthagenians, the Romans had destroyed 317,600 lives. During twenty-five years prior to 180 B.C., they had killed and captured in Cis-Alpine Gaul, which corresponded to the valley of the Po, 250,000.

The city of Padua was able to raise an army of 120,000 men. Before Christ 212, the island of Sardinia contained 1,000,000, and so much of Sicily, as was dependent on Syracuse, 600,000. When all these indications of a dense population are considered, the census of Italy might well have reached twenty-three or twenty-four millions, at the era of the greatest power of Rome; which is about the same number as at present.

The kingdom of Carthage must have embraced as many more, or she would not have been so much hated and feared as a rival. The Numidians alone, at one time during the long contest between Rome and Carthage, were able to raise 300,000 soldiers, each of whom, probably, represented *ten persons*. For the Roman Empire in Europe, Asia and Africa, in the reign of Augustus, the estimate of Mr. Gibbon is 120,000,000. At the present time the population of the same area is not far from 170,000,000. Gibbon fixes the population of Italy in A.D. 1781, less than an hundred years since, at 10,000,000; but this does not include all of the territory of the Italy of the Cæsars.

THE JEWISH NATION.

There are three enumerations on record, of the men of war in the twelve tribes of Israel, but no complete census of the people. The first was taken at the time of their exodus from Egypt, which is reasonably well fixed at 1491 B.C., and the second near their entrance into Canaan about 1453 B.C. Again in the time of David, about 1015 or 1017 B.C., a third and last military census was taken. Although these three enumerations go only a little way towards the establishment of a reliable ratio of increase, I refer to them with more detail, because they are more full and more ancient than those of any other nation.

Among chronologists, there is a wide difference in regard to the time which elapsed, between the migration of Jacob and his family to Egypt, and their flight to the deserts of Arabia. By the Vulgate or Douay Bible it is 215 years; by Josephus and the Samaritan text, 210, and by the Jewish traditions, 312. The apostles Paul and Stephen speak of it as lasting 400 and 430 years. Lepsius places the exodus in 1314 B.C., which would add 117 years to their stay in Egypt, beyond that given in our Bibles and by Josephus.

It is also impossible to determine how many persons composed the family of Jacob. At least seventy-five are mentioned in the Septuagint, and seventy in our version; but the wives of his sons are not included, who might extend the family to *one hundred persons.* Assuming this to have been the number, I have taken the case of the black race in the United States, as an instance of rapid multiplication; and have estimated the rate of increase of the Jews on that basis, during their stay in Egypt. Both people were in a state of servitude, and lived in regions where food was abundant. In the case of the Israelites, their family pride, their customs and their religion, placed them in a state of nearly perfect isolation. There is no instance of a people, who have adhered more rigidly to separation from the rest of mankind, and to purity of blood. The black race in the United States, since 1810, was not strengthened by importation, and thus it presents the best modern instance, of computing the rate of a *purely natural increase.* Between 1810 and 1860 inclusive, a period of fifty years, the census of the United States shows this rate to have been, a fraction over *twenty-six per cent.*, compounded every *ten years*, or *one hundred per cent.* in about thirty years. On this ratio the family of Jacob, counted as one hundred persons, would require four hundred years, to reach the number of 1,034,713. The two enumerations in the wilderness, which were less than forty years apart, differ very little. According to Josèphus, the number of men over twenty years of age, able to go to war, was 601,630. The largest number given in the Vulgate, and in our version, is 603,550; differing only by 1,950 men. None of the Levites are included. The proportion of able bodied men, to the entire population, varies in different countries. In 1860 in the United States, the number of enrolled militia, between eighteen and forty-five years of age, was about *one in nine.* In England and France it is materially less. For the purpose of arriving at a surmise of the Jewish population, based upon the military census, I assume their fighting men each to represent eight people, the Levites excepted; and their number to have been in round numbers 600,000, at the exodus, 1491 B.C.

On this basis there should have been in the wilderness of Sinai 4,800,000 people. The natural increase of the black race in the United States, commencing with 100 persons, would reach only about one-quarter of this number, in a period of 400 years; or

nearly double the usually received period of the stay in Egypt. If the negro rate should be doubled, the numbers indicated by their military strength, as above given (4,800,000), might have been reached in about 250 years. It evidently requires a longer period than 210 to 217 years, the 312 years of the Rabbis, or even 393 years, as intimated by Lepsius; unless there was a larger number of progenitors than 100 in the family of Jacob.

Everything is thus too vague, to derive a reliable ratio. Among the tribes, whose men able to draw the sword are recorded in the second registration, there is a great difference in their numbers. Judah could raise 75,500 and Simeon but 22,200, fighting men.

The date of the third and last census, under King David, has been the subject of little discussion, the differences being only a few years. It occurred between 1017 and 1015 B.C., and therefore about 440 years after the last enumeration in the wilderness. But a large discrepancy exists between the returns, as given in II Samuel, chap. 24 and I Chronicles, chap. 21. There is no reasonable room to doubt that both refer to the same enumeration, but in the recorded results there is a difference of 270,000 fighting men. The Levites and the tribe of Benjamin are not included, and as the whole thing was distasteful to Joab and his captains, to whom the business was intrusted, little care was probably taken with the work. By the lowest figures, there were in Judah 500,000 fighting men, and in Israel 800,000, making a total of 1,300,000. If the tribe of Benjamin could be added, it would somewhat reduce the discrepancy of 270,000; but the text does not warrant this, and even then the numbers would not be sufficient to harmonize both accounts. Assuming the same proportion as before, *of eight people to one soldier*, there should have been in David's time 10,400,000; besides Levites and Benjamites. Whether this is near the truth or not, the *comparison* between the time of Moses, and that of David, on the same *basis of fighting men*, cannot be far wrong. During more than 400 years of prosperity the soldiers and the people had little more than *doubled in numbers*. When this is contrasted with the enormous increase from Jacob to Moses, requiring a rate of more than fifty per cent. every ten years, it is apparent, that we are as yet unable to draw satisfactory conclusions. Probably the chronology is at fault as to the stay in Egypt.

It was not long after the close of David's reign, before civil and

foreign wars led to a rapid destruction and dispersion of the Jews; from which they have not yet recovered. In the next 400 years the nation was disintegrated.

Mr. Smith, the author of the *Dictionary of the Bible*, estimates the number of Jews in Palestine, in the time of Jehoshaphat, about 900 B.C., at 6,000,000. From the numbers who were slain or captured, in their wars with the Romans, the nation must have been numerous during the reign of the emperors, who succeeded Augustus. From the siege of Jerusalem under Titus, A.D. 79, to the time of Caligula, more than 2,000,000 were slain or captured.

An estimate made A.D. 1858, including Jews in all parts of the earth, gives but 4,658,000 persons. Their strength does not differ materially now, from what it was 3,000 years ago; and therefore no law of development can be derived from them.

Since the year A.D. 1800, when the European nations began to take a more full and exact census of their people, there has been found to be a more rapid and regular rate of increase in population than ever before, but the ratio of Europe is far below that of the United States.

ENGLAND AND WALES.

According to English statisticians, there was very little increase from the time of the Norman conquest, to A. D. 1337; a period of 271 years. In 1337 they fix the population at about 2,300,000.

In 1696, 359 years afterwards, it had about *doubled;* the estimates then made with great care, showing about 5,500,000. Again in 1801, at the first complete census, there were about 9,000,000, or very near double, covering a period of 105 years. At the census of 1861, the population fell a little short of 100 per cent. over 1801. In England and Wales, the rate of increase has been little affected by emigration or destructive wars.

The average decennial increase, derived from exact returns since 1801, through a period of 60 years, is (14.3) *fourteen and three-tenths per cent.*, under which the people double in numbers in about that time. In France the decennial rate is a trifle less than (5) *five per cent.*, requiring about (150) *one hundred and fifty years*, to double the population.

The above data, with some additions, are here repeated in a more condensed form in the following table.

INDICATIONS OF THE ANCIENT POPULOUSNESS OF NATIONS.

CITY OR PROVINCE.	ERA.	NUMBERS.	AUTHORITY.
Athens	500 B. C.	284,000	Diodorus Siculus
Agrigentum (Sicily)	400 "	200,000	" "
Sybaris (Greece)	300 "	300,000	Hume
Rome	First century	1,200,000	Gibbon
Carthagena (Spain)	Punic wars	Next to Rome	Napoleon's Life of Cæsar
Syracuse (and dependencies) Sicily	212 B. C.	600,000	" " " "
Padua (Lombardy)	203 "	120,000 fighting men	" " " "
Seleucia (Asia)	200 "	600,000	Hume
Antioch (Palestine)	200 "	300,000 free men	"
Alexandria (Egypt)		Little inferior to Rome	"
Carthage and dependencies (Africa)	3d Punic war	700,000	Strabo
Gaul	Time of Cæsar	400,000 killed	Hume
Grecian Confederacy	" " Philip	1,920,000	"
Roman Empire	" " Augustus	4,101,077	"
Free Citizens	" " Claudius	6,945,000	Encyclopædia Britannica
Scythians	521 B. C.	70,000 fighting men	Louis Napoleon's Life of Cæsar
Sardinia	212 "	1,000,000	" " " " "
Cis-alpine Gaul	181 to 153 B. C.	250,000 killed and captured	" " " " "
The Huns under Attila	415 A. D.	750,000 fighting men	Creasy
Spain	200 B. C.	317,000 killed and captured	Life of Cæsar

The foregoing, like all statistics of ancient populations, show many incongruities, but they are also of sufficient value to show that nations have not progressed in numbers with regularity. All of them have experienced diminution as well as increase. Their decadence is a rule as much as their progress; and if it is a rule of nations, it must tend to diminish the ratio of increase of the population of the earth. The wars of the ancients, carried on by swords, spears, arrows and clubs, used in hand-to-hand combats, were much more fatal than those of our day. Their wars were also much more prolonged, and every way more exhausting. Within three hundred years the expectation of life has about doubled.*

The ancients had very limited means of transportation, especially for heavy articles, such as constitute the food of man. On large rivers and along the shores of oceans, it could be done; but only in a limited way, compared with modern commerce. Their mode of cultivation soon exhausted the soil. In countries which were interior, and thus cut off from supplies, horrible famines were common, such as we have recently known in Persia. But in favorable regions, especially where the climate is genial, the ancient population frequently exceeded the modern, in territorial density.

There is in all parts of the world evidence of people who lived prior to any historical records. In Italy, the Etruscans had built structures of respectable size, which were ancient and in ruins, when Rome was founded. Of the early nations which inhabited this continent, we know very little.

The Peruvians, of the era of the Incas, were preceded by a race whose architectural remains and whose character were a mystery to them.

In Central America there were people of more antiquity than the Aztecs or Toltecs, whose monuments still exist.

It is the same in the valley of the Mississippi, where the mound builders once lived. Back of them all, in Europe, are the relics of the dwellers in caves; the earliest type of mankind. Between Ezion Geber on the Red Sea, along the old route to the valley of

* In Geneva accurate registers have been kept of the yearly average of life since 1560, which was then 22 years and 6 months; in 1833 it was 40 years and 5 months. Thus, in less than 300 years the average duration of life has nearly doubled. In the fourteenth century the average mortality in Paris was one in 16; it is now about one in 32. In England the rate of mortality in 1690 was one in 33.

the Jordan, there are inscriptions on the rocks, in languages that are otherwise unknown.

AMERICA.

In North America there was, in the valley of the Mississippi, the race of the mounds; at least as ancient as the era of Christ. On the waters of the Pacific were the Pueblo Indians, who erected large edifices of stone.

In the more northerly parts of North America, and along the Atlantic coast, were the red, or copper colored tribes; which, however, were never very numerous, because they were always hunters; not cultivators of the soil. South of the United States, there was probably as large a population two thousand years since, as there is now, which is shown in the following table:

South America, in 1851 (uncivilized Indians excepted)	19,192,020
West Indies	3,500,000
Central America (wild Indians excepted)	2,019,000
The Indians of the United States, 1850	294,113
Mexico (1857)	7,859,564
Mound builders, a numerous people, say	500,000
Pueblo and other Indians, say	300,000
Total	33,664,697

Forty millions would be a large estimate for America in the first century of our era.

ESTIMATED POPULATION OF THE EARTH ABOUT THE CHRISTIAN ERA.

COUNTRIES.	NUMBERS.
Roman Empire, including *Europe* west of the Neimen and the Dnieper. *Asia Minor*, Palestine and North Africa, according to Gibbon	120,000,000
Asia, south of the Himalayas, including *Hindostan*, *Persia*, the *Malay Peninsula*, and the Islands of Oceanica (conjecture)	100,000,000
China and Japan (conjecture)	50,000,000
Tartars, north of the Himalayas, Scythians and Teutons, north of Europe, say	25,000,000
Central and South Africa, say	25,000,000
America, say	40,000,000
Total	360,000,000

The United States has been so much affected by immigration, that its rate is no guide in the pursuit of the ratio of *natural in-*

NCIENT AN

, ETC.	5TH ENUMERATION, ETC.		
PERIOD OF DOUBLING.	NUMBERS.	PERIOD OF DOUBLING.	AUTHORITY, ETC.
406 years.	4,658,800 3,165,803	Decrease.	Physical Geography. Cyclopædia of History.
	388,000,000	81 years.	Johnson's Physical Atlas.
	8,892,536		
	19,927,529	50 years.	
150 years.			
	23,191,876	26 years.	Census.
175 years.			

crease; neither is the low rate of periods prior to the present century a guide in predicting for the future. There are now so many causes in active operation to increase the human family, to prolong and to preserve life, that no calculations for the past can be based upon our present condition.

The figures I have presented only show that a very long period must have elapsed between the first appearance of man upon the earth, and the earliest historical records.

If the human race were no more prolific prior to the Christian era than it has been since, the day of its origin can readily be put back to the close of the glacial period. If we admit that the Creator originated species as soon as the earth was in a fit condition for their self-existence, the period of the genesis of man must have been at least as early as that last change in the condition of the earth.

All the facts within my reach, and all the estimates worthy of consideration, are embodied in the annexed table, constructed on the basis of the periods occupied in duplicating the population of nations.

ON THE RELATIONS OF THE NIAGARA AND LOWER HELDERBERG FORMATIONS, AND THEIR GEOGRAPHICAL DISTRIBUTION IN THE UNITED STATES AND CANADA. By JAMES HALL, of Albany, N. Y.*

IN proceeding to the discussion of this subject, I propose in the first place to cite a paper read by Mr. A. H. Worthen at the Troy Meeting of the American Association, and published in the Proceedings under the following title:

"*Remarks on the Relative Age of the Niagara and so-called Lower Helderberg Groups. By A. H. Worthen, of Springfield, Illinois.*"

"Recent investigations have developed certain facts, bearing upon the question of the relative age of the above named groups,

which we desire to present in a brief manner for the consideration of those who are especially interested in stratigraphical geology.

In northern and western Illinois, from the mouth of the Illinois River northward to the Wisconsin line, the Upper Silurian division of the palæozoic series is represented by buff, gray, or yellowish-gray dolomites, sometimes in remarkably even beds, as at Joliet and Grafton; and at other localities by concretionary masses, with but faint traces of stratification, as at Bridgeport, near Chicago, and at Port Byron and Leclare, at the head of the Upper Rapids on the Mississippi River. They range in thickness, from seventy-five to three hundred feet, and directly overlie the shales and argillaceous limestones of the Cincinnati group of the Lower Silurian series. These dolomites are quite fossiliferous, and afford many characteristic Niagara species, among which we may mention *Pentamerus oblongus*, *Spirifer radiatus*, *Calymene Blumenbachii*, *Caryocrinus ornatus*, *Orthoceras undulatum*, etc. From the Bridgeport locality alone, nearly one hundred species of fossils have been enumerated, a large number of which are specifically identical with those found in the Niagara beds of New York and Canada; and, so far as we are aware, all Western geologists are agreed in considering these dolomites to be the stratigraphical equivalents of the Niagara group of New York.

In southern Illinois we find these dolomites replaced by a series of silicious and argillaceous limestones, forming a group two hundred and fifty feet or more in thickness, which, like the dolomites of northern Illinois, rest directly upon the Cincinnati group, and are immediately succeeded by Devonian strata. At the base of this group of silicious limestones there are some reddish mottled beds, from ten to twenty feet in thickness, that in color bear considerable resemblance to the Medina sandstone of New York; and these mottled limestones pass gradually into the buff and gray silicious beds that constitute the upper and main portion of the group. Fossils are rare in the lower portion of the group here; but the mottled limestones contain some *Orthoceratites*, and joints of large *Crinoidea*, while the middle and upper portions are locally quite fossiliferous, and have afforded many of the characteristic species of the so-called Lower Helderberg group, among which are the following; *Orthis subcarinata*, *O. oblata*, *Cœlospira subcarinata*, *C. imbricata*, *Spirifer per-lamellosus*, and *Platyceras spirale* of Hall, and *Acidaspis hamatus* of Conrad, together with species closely resembling, if not identical with, *Merista princeps*, *Platyceras pyramidatum*, *P. unguiforme*, *P. incile*, and *P. multistriatum* of Hall.

In the first volume of the 'Report on the Geological Survey of Illinois,' these silicious limestones of the southern portion of the state, and the dolomites of northern Illinois, were regarded as the stratigraphical equivalents of the Niagara group, and were included together as representing a single division of the Upper

Silurian series; but, subsequently, in a corrected section of the Illinois strata, published in the introduction to the second volume, we were induced, from the dissimilarity of the fossils from the different sections of the state, to regard the silicious limestones of southern Illinois as the representatives of a higher geological horizon, and therefore placed them above the dolomites of the northern part of the State, as the equivalents of the so-called Lower Helderberg group. We are now, however, fully satisfied from a further examination of these Upper Silurian strata, over a more extended region, that our first conclusion was correct, and that these silicious limestones and dolomites represent the same geological horizon, and that the difference in the specific character of their fossil contents is entirely due to the changes in the oceanic conditions under which they were deposited, and not to the different ages of the sediments themselves.

South of the Ohio River, these Upper Silurian strata are found well exposed in Tennessee, in the counties of Wayne, Perry and Decatur, on the Tennessee River, outcropping over a wide area and affording numerous species of fossils in a fine state of preservation. The base of the group here consists of reddish and mottled limestones, very similar to those in southern Illinois, and contain *Orthoceras undulatum*, and joints of large crinoids in great abundance. These red limestones are succeeded by a series of greenish-gray shales, and shaly argillaceous limestones, containing *Caryocrinus ornatus*, *Calymene Blumenbachii*, *Sphærexochus mirus*, *Platyceras Niagarense*, *Pentamerus oblongus*, *Orthis hybrida*, *O. elegantula*, etc., associated with such Lower Helderberg forms as *Pentamerus galeatus*, *Spirifer per-lamellosus*, *S. macropleura*, *Merista lævis*, *Rhynchonella ventricosus*, and many others, showing that the fossils of these so-called groups are here intermingled through the same strata, confirming what we had already assumed to be true in Illinois, that the Upper Silurian beds of the West constitute but a single group, and consequently that the term Lower Helderberg, as applied to a group distinct from the Niagara, is superfluous. We recollect that, on visiting the locality of these so-called Lower Helderberg limestones in the Schoharie valley some years ago, we observed these limestones resting immediately upon undisputed Lower Silurian beds there, and, in explanation of their occurrence in this apparent abnormal position, we were told that the Niagara group was supposed to have thinned out to the eastward, and that these Lower Helderberg limestones took their place. But is it not quite as probable that there has only been a change in the lithological character of the beds in their eastern extension in New York, resulting there, as in Illinois, in a decided change in the specific character of the fossils which they contain, and that the Upper Silurian beds at Schoharie are the exact equivalents of the Niagara shales and limestones in the western part of the State?

To recapitulate, then, the facts as they are presented in the West; we find that the dolomites of northern Illinois contain only Niagara fossils, and the silicious limestones of the southern portion of the State contain only those considered characteristic of the Lower Helderberg group; while the beds in Tennessee, occupying the same stratigraphical position with the dolomites and the silicious limestones of Illinois, have Niagara and Lower Helderberg fossils intermingled indiscriminately through the strata. Hence we conclude that the so-called Lower Helderberg group has no real existence as a distinct group of Upper Silurian strata, and that the name, being superfluous, should be dropped from the nomenclature of the American rocks."

It is here proposed, in an article of less than three pages, to discard entirely from the geological series and geological nomenclature a well recognized group of strata; well known and clearly defined for more than one thousand miles in extent of country, spreading diagonally over nearly or quite fifteen degrees of latitude, while its undulating and repeated outcrops, owing to anticlinal erosion, add some hundreds of miles more to its known exposures.

The result of tedious and careful field investigations in the working out of hundreds of sections in various parts of the country have been supplemented by the study of large collections of numerous species of fossils, and the final comparison of all these fossils, from the far northeast on the St. Lawrence to Tennessee on the southwest — from the Mississippi valley on the west, from the states of Iowa, Illinois, Wisconsin, the Islands of Lake Huron, and Canada West (or Ontario), together with the more critical study of the rocks and fossils within the limits of the state of New York — are all to be set aside, and a simple *assertion*, unsupported by sections, by fossils, and I may say by a single fact of importance, is to be substituted for all the labors of thirty years.

This assertion comes from a gentleman holding the important and responsible position of State Geologist of Illinois, whose name is associated with so much of the geology and paleontology of the West as to give currency, if not authority and authenticity, to what he may say: — and certainly he ought not, without good reason and authentic data, make such assertions nor put such a paper before the American Association for the Advancement of Science.

But will the geologists of the United States accept this so-called

determination of the identity of the groups of strata known as the NIAGARA and the LOWER HELDERBERG?*

But Mr. Worthen is not original in this view of the relations of the two groups of strata. He has merely revived an old and discarded error. The same assertion was long ago made in the Geological Reports of Pennsylvania and elsewhere; and was at one time the generally accepted belief among geologists. Professor Rogers, in a paper upon Niagara Falls published, I believe, in 1832, takes this view of the relations of these formations, and includes also the limestone of Black Rock under the same designation. It is not surprising that at that period, when no critical examinations had been made, when we had no knowledge of paleontology as a guide in the more obscure and difficult points, that great surface features should have been taken as guides in the determination of geological formations. It happened in this case that the great escarpment of the Niagara at Lewiston and Queenstown was regarded as the extension of that of the Helderberg and the south side of the Mohawk valley. The limestone of Black Rock, though so far separated from Niagara, was regarded as a part of the same; the features in the West being more subdued, as was supposed.

This in brief was the condition of our knowledge and belief regarding these formations at the beginning of the New York Geological Survey, and for some time afterward.

The one horizon which above all others was at that time regarded as fixed beyond question was that of the salt-bearing strata. This formation, at its base bearing a great thickness of red and mottled shales and marls, succeeded by gray, ash or drab colored beds of similar characters, and finally hard beds of limestone, was regarded as clearly defined from Saltspringville in the Mohawk valley, by way of Syracuse, Montezuma, and thence westward along the base of the Limestone Terrace from Rochester to Lewiston.

Throughout this entire extent salt springs had been discovered, and brines of varying and different qualities were known to exist. No doubt of the nature, age, or identity of the formation, from

*Of late years, in certain quarters, it has been only necessary to contradict what has been done in the State of New York, or by persons in her employ, both in geology and paleontology, to have the statement accepted on bare assertion. I might instance examples too numerous to be creditable to the acumen and good sense, to say nothing of the scientific ability, of those who propose or accept such conclusions.

Herkimer county to the Niagara River at Lewiston, had ever been expressed, or, so far as I know, entertained by any one. Now, though this may seem irrelevant to the question before us, it nevertheless lies at the foundation of the error then prevalent, regarding the Niagara and Helderberg formations; and is intimately connected with the greater error now sought to be revived in the paper under consideration.

It was not until the close of the field work of 1838 that this question came before the assembled members constituting the Commission of the New York Geological Survey. The youngest member of that body had asserted, as the result of his investigations, that the rocks at the base of the Niagara Terrace, consisting of red, gray and mottled marls and sandstones, were not the continuation of the salt bearing beds of Onondaga, and elsewhere to the eastward, but a lower formation; that the Niagara limestone, so largely developed at Niagara and Lockport, was not a continuation of the limestone of the Helderberg, but a distinct formation; having its greatest development towards the west, and gradually thinning to the eastward; and that instead of lying above the Salt formation it lay beneath it: that the Salt formation, extending westward from Syracuse, passed to the southward of the Niagara Terrace, and formed the broad belt of flat country to the south of the range, which is so marked a feature from the Genesee River south of Rochester to the Niagara River at Tonewanda; thus separating, by a distance of several miles, the limestone of Niagara and that of Black Rock.

The conditions which originally led to this misapprehension of the relations of the different formations, are, the flat marshy country from the outlets of Seneca and Cayuga lakes to the northward, which has obscured the outcrops, and beyond this, in Wayne county, the great accumulation of drift, which has deeply covered the rock over a large area. If to these we add, that in the earlier geological explorations the line of the Erie canal was that principally travelled, — that the passage from the red and gray marls of the Onondaga region to the red and mottled marls of the Medina Sandstone at Rochester and westward of the Genesee River was through an alluvial or drift country which concealed the underlying rock formations, — the supposed identification of the two formations is not surprising.

That such views should prevail before continued and connected

observations had been carried on, we are prepared to understand; but after nearly forty years of observation, and after the relations of all these rocks have been fully understood for thirty years or more, I submit that it is not worthy of the credit of the American Association to allow such a paper to pass into its publications without serious consideration. Personally I may be interested in this question more than others, since I have published a volume principally upon the paleontology of the formation or group here proposed to be discarded as having no separate or distinct existence in the series; but the science of geology, and those who pursue that science, have an interest in this question far superior to one of mere personality.

Geological relations and geographical extension of the groups in question.

Starting from the typical locality of the Niagara group, where we have of the shale and limestone a thickness of something more than two hundred feet, and tracing the outcrop in an easterly direction, we find a very gradual but pretty constant thinning of the beds of the formation, so that at a point one hundred miles east of the Niagara River, it has a thickness of scarcely one hundred feet. Farther east, in Oneida county, the formation is still thinner, and in some places has become in part or almost entirely a brecciated and concretionary mass, with few or no fossils.*

Going eastward it becomes still further attenuated, but can still be traced both in its physical aspect and outcrop, and by its fossil contents. In the neighborhood of Schoharie, Cobleskill, Cherry valley, etc., it is known as the Coralline Limestone, from its abundance of corals. These are principally identical with the corals of the Niagara group in western New York; and most of the species of Brachiopoda which occur in a condition to be recognized, are similar or identical with Niagara forms, while there are several species quite distinct from those of the Niagara group in the west. The upper limit of *Halysites catenulatus*, so far as known in New York, is in the Niagara limestone; and this fossil occurs in the coralline limestone at Schoharie and at Litchfield in Herkimer county.

I have given in vol. ii, Pal. N. Y., p. 321, more at length my

* In that part of the state the formation is so insignificant, that it was originally regarded by Mr. Vanuxem as a subordinate member of the Protean or Clinton group; and was only recognized by him as a distinct formation in 1839; after the investigations in the western counties had shown its true relations and importance.

reasons for regarding this coralline limestone as the easterly continuation of the Niagara group; and since the time of that publication, I have made numerous observations upon the relations of the coralline limestone, all of which have tended to confirm the views there expressed. This coralline limestone in its attenuated form may be recognized in the valley of the Hudson River underlying the water-lime formation at numerous localities.

Now returning along this line of outcrop to the Niagara River, and following the formation to the northwest, we find it expanding in thickness and area through Canada West to Cabot's Head; appearing in the islands along the eastern and northern side of Lake Huron, and stretching across the peninsula from St. Joseph's River to the outlet of Green Bay; thence occupying the principal part of the peninsula between Green Bay and Lake Michigan, it expands to the southward beyond the southern limits of that lake, and thence trends to the west and northwest through Illinois and Iowa. From the Niagara River westward, the formation is chiefly a magnesian limestone, and in many localities carries an abundance of fossils; both the physical and paleontological evidence leave no doubt as to the age and relations of the formation.

Returning again to the eastward and southward, we find that the anticlinal movement, which elevated the islands in the western part of Lake Erie, has brought up the Niagara formation in the adjacent parts of Ohio, where it is marked by the presence of a greater or less proportion of its characteristic fossils. Here it stretches in a low axis for miles to the south of the lake, and thence spreads and outcrops on either side of the rocks of the Hudson River and Trenton age, which form the central or lower visible portion of the Cincinnati axis.

Following this direction it extends through Kentucky and Tennessee, everywhere carrying its characteristic fossils.

Throughout all this extent, until the formation reaches Tennessee, there is no question raised as to the identity and purity of the Niagara group. Here, it is said that the fossils of the Niagara are mingled with those of the Lower Helderberg group. And again, on the Mississippi River, in Illinois and Missouri, we are told that this mingling of the fossils of the two periods occurs.

But before proceeding to discuss this part of the question, let us for a moment give attention to what is termed the Lower Helderberg group in its typical localities.

In the Helderberg Mountains in Albany county, and in Schoharie along the valley of the Schoharie Creek, and in the Cobleskill valley, we find everywhere a series or group of limestones, of which we distinctly recognize four members; these are known, in the ascending order, as Tentaculite limestone, Lower Pentamerus limestone, Shaly limestone and Upper Pentamerus or Scutella limestone. There is in some places for miles in extent a mass of Stromatopora limestone between the Tentaculite and Lower Pentamerus limestones. These together constitute the Lower Helderberg group, forming in Albany county the base of the Helderberg mountains, and everywhere succeeded by the Oriskany sandstone, Cauda-galli and Schoharie grit and Corniferous limestone, and these, in the summits of the hills by the arenaceous shales of the Hamilton group.

This group of limestones is everywhere characterized by the presence of fossils, often in immense numbers, and specifically, with very few exceptions, quite unlike the fossils of the rocks above or below this horizon. From the Helderbergs, and the valley of the Schoharie, we are able to trace the formation to the westward through the northern part of Otsego, and the southern part of Herkimer and Oneida counties; and, according to Mr. Vanuxem, it is recognized in the eastern part of Onondaga county, by the presence of some of its peculiar fossils. From the Helderberg mountains the group gradually thins to the westward; and in Herkimer county the divisions of the several members are scarcely recognized, the entire mass becoming more completely calcareous but still charged with an abundance of the characteristic fossils of the group. West of Onondaga county the place of the formation is often recognized by a stratum of hard, compact limestone lying beneath the Oriskany sandstone.* It is quite evident that the force of the entire group diminishes in a westerly direction.

Returning to the point of departure in the Helderbergs, we are able to trace the rocks of this group, in their clearly defined and unmistakable characters, through the eastern counties of New York to the limits of the state of New Jersey. In the northwest part of that state the formation has been distinctly recognized by Professor Cook. The same has been fully described

*In some former Reports on the Geology of the western counties, this rock is described as worn or eroded previous to the deposition of the Oriskany sandstone.

as the "Limestone formation, No. VI" in the geological survey of Pennsylvania, where it appears in numerous outcrops, and extends thence through the western part of Maryland and through Virginia, along the Appalachian range into Tennessee.

Nowhere throughout this extent of country, as far as Virginia, has any one shown, or attempted to show, the mingling of lower Helderberg and Niagara forms among the fossils. In the large collections which I possess from Maryland and Virginia, I have never observed the least evidence of such mingling; and in Maryland and the adjacent parts of Virginia I can speak from personal observation that the formation is as well defined physically as in any part of New York.

Let us now look to the northeast, where the geological survey of Canada has traced the lower Helderberg formation from Montreal to Gaspè. Having examined large collections of these fossils from the Gaspè region, and others from near Montreal, I have never seen the least indication of a mingling of any other forms with those characteristic of the lower Helderberg.

We have now traced this formation from the forty-third parallel in the state of New York to about the thirty-fifth parallel of latitude in Tennessee, and over the greater part of this extent we have no knowledge of a mingling of the fossils of the two groups or formations. Again, from the vicinity of Montreal to Gaspè, a distance of some seven hundred miles, the formation wherever known carries its characteristic fossils.

This group is likewise recognized in the state of Maine, where it is characterized by numerous well known fossils; and it is not improbable that it may be equally so in the eastern townships of Canada and in the belt of limestones extending through Vermont to the northern part of Massachusetts.

Having thus hastily sketched the ground occupied by these two groups of strata, we may now consider their relations to each other, and the evidence of the mingling of the fossils which would render it necessary to relieve the nomenclature of geology of one of these names, heretofore adopted, and in general use wherever geology is written or spoken.

I will here cite a single sentence from the paper referred to:—

"We recollect that, on visiting the locality of these so-called lower Helderberg limestones in the Schoharie valley some years ago, we observed these limestones resting immediately upon undisputed

lower Silurian beds there; and, in explanation of their occurrence in this apparent abnormal position, we were told that the Niagara group was supposed to have thinned out to the eastward, and that these lower Helderberg limestones took their place."

Fortunately or unfortunately there is no evidence given as to the authority or by whom "*we were told*" that the Niagara group had thinned out to the eastward. In the first place let us inquire as to the fact of the lower Helderberg "limestones resting immediately upon undisputed lower Silurian beds there" or elsewhere. Having been familiar with the Schoharie valley, and having made numerous sections, and explored long lines of outcrop in that valley, in the Cobleskill valley and in the Helderberg, I have never been able to see the lower Helderberg limestones resting upon lower Silurian rocks. On the contrary, the section of strata everywhere shown is the following, as given on the diagram, from the sandstones of the Hudson River group to the Oriskany sandstone:—

	Oriskany sandstone.
Lower Helderberg group.	Upper Pentamerus limestone. Shaly limestone. Lower Pentamerus limestone. Tentaculite limestone.
	Water-lime formation.
Niagara group =	Coralline limestone.
	Green shales with Iron pyrites.
Lower Silurian	Sandstones and shales of the Hudson River group.

Everywhere the lower member of the lower Helderberg group is unmistakably separated from the sandstones of the lower Silurian age by three distinct and usually well marked members of the series.

Tracing the lower Helderberg formation from this point for sixty miles westward, we have the following section:—

	Oriskany sandstone.
Lower Helderberg group.	* Shaly and lower Pentamerus limestones. Tentaculite limestone.

* The upper Pentamerus limestone is not developed as a distinct member of the group.

Water-lime formation.
Onondaga salt group=Red and gray marls.

Niagara group=Coralline limestone.

Clinton group= { Green shales and sandstones with calcareous bands containing interstratified beds of red hematite.

Medina sandstone.
Lower Silurian = Gray and bluish-gray sandstones and shales of the Hudson River group.

Everywhere the lower member of the lower Helderberg group rests upon the water-lime formation; and the latter is always present, separating the former from the coralline or Niagara limestone. At a distance less than one hundred miles farther west, in a line from Seneca or Ontario to Oswego county, we have a section showing the following formations:—

Oriskany sandstone.
Lower Helderberg group represented by { Compact grayish-blue limestones in a band of a few feet in thickness.

Water-lime formation.
Onondaga salt group with salt springs and gypsum beds, more than 1,000 feet in thickness.
Niagara group.
Clinton group.
Medina sandstone.
Hudson River group.

At this point the Niagara group is separated from the continuation of the lower Helderberg group by strata of more than 1,000 feet in thickness.

Everywhere throughout New York the lower Helderberg group is underlaid by the water-lime formation; and the same is true in New Jersey, Pennsylvania, Maryland and Virginia; and everywhere throughout New York and Canada West, and in Wisconsin and Iowa the water-lime formation lies above the Niagara group,

or its representative, the coralline limestone.* In no case do these two formations come together except where the water-lime formation is absent.

Certainly these formations are widely enough separated to constitute distinct groups over the areas named.

It is suggested in the paper cited that the difference between the fossils of the lower Helderberg group in eastern New York, and those of the Niagara group in the central and western part of the state, is due to "a change in the lithological character of the beds in their eastern extension."

In the western part of the state, the Niagara group is composed of calcareous shales and dolomites. The lower Helderberg group in the eastern part of the state consists, in its lower part, of thick and thin bedded dark or black limestones, with shaly partings, and sometimes with thicker intercalated shaly layers; to these succeed the heavy bedded limestone with *Pentamerus galeatus*, which by the intercalation of shaly matter becomes thin bedded, and passes by almost insensible gradations into the "Shaly Limestone," and finally to a silico-calcareous shale.† The higher member, in many localities, is the thin bedded Upper Pentamerus limestone, while at Becraft's mountain and in the Helderberg the upper member is a heavy-bedded encrinal limestone sometimes known as the Scutella limestone, from the presence of great numbers of the bases of *Aspidocrinus*. The shales of the Niagara group and their contained bands of limestone, which are the most highly fossiliferous portion of the group in New York, are not dolomitic; and it seems a most extravagant supposition, that the slight lithological differences in the composition of the strata could produce an *entire change* in the fauna; presuming the deposits to be of the same age.

We now come to the consideration of the last paragraph of this remarkable paper, in which we have the following summary:—

"To recapitulate, then, the facts as they are presented in the West; we find that the dolomites of Northern Illinois contain only Niagara fossils, and the siliceous limestones of the southern portion of the State, only those considered characteristic of the lower

*It is true that over a considerable part of the lake region, the water-lime and Onondaga salt group have been eroded from above the Niagara formation; the place of these softer formations being occupied by the lakes. See Foster and Whitney's Report on the Lake Superior Land District.

†The physical aspect of this portion of the group is preserved in the '*siliceous limestones*' of this age in the southwest.

Helderberg group; while the beds in Tennessee, occupying the same stratigraphical position with the dolomites and the siliceous limestones of Illinois, have Niagara and lower Helderberg fossils mingled indiscriminately through the strata. Hence we conclude that the so-called lower Helderberg group has no real existence as a distinct group of upper Silurian strata, and that the name, being superfluous, should be dropped from the nomenclature of the American rocks."

The value of this conclusion will be best appreciated from the fact that in southern Illinois and adjacent parts of Missouri the limestones holding the characteristic Niagara fossils lie beneath those containing the characteristic lower Helderberg fossils; and that we *never* "have Niagara and lower Helderberg fossils indiscriminately mingled through the strata;" unless it be in the débris along the outcrop; and I assert this from my own observation. The same is true of the beds in Tennessee; and though the collections of fossils made on the outcrops and among the débris do contain fossils of the Niagara and lower Helderberg formations mingled together, this is not true of the rocks *in situ*. In this opinion I do not rest alone; and it is only necessary to consult the report of Professor Safford to show that he finds both the rocks and fossils of the lower Helderberg formation distinctly separated from, and lying above, those of the Niagara group.

In some localities Professor Safford asserts that he finds fossils of the two formations mingling *along the line of contact*, which, in the absence of all intervening beds, may very well happen. And this fact, so far from proving the identity or synchronism of the formations, is a very important proof of their distinction in order and in time.*

In reviewing the facts, and considering the known range and extent of the Niagara and lower Helderberg groups, their close approximation or actual contact over large areas, and their wide separation in other places, we are compelled to the conclusion that there are no two groups, of similar composition, in the entire palæozoic series, which are so clearly distinct and which can be unmistakably traced over so wide an area of country, both in their physical and lithological character, as well as in their contained fossils.

That there are designations among some of the formations

* We may inquire also whether it may not be inferred that the living organisms of the lower Helderberg period were spread over a sea bottom covered with the dead organisms of the preceding period and became mingled in this manner.

which are superfluous, we are willing to admit; but the proposition to drop from the system one of the most widely distributed formations of the country, whose geological position and relations, and the fossil contents of which are so well known, is scarcely the proper mode of improving "the nomenclature of the American rocks."

NOTES ON LIPARIS, CYCLOPTERUS AND THEIR ALLIES. By F. W. PUTNAM, of Salem, Mass.

ABSTRACT.

HAVING my attention directed to this group of fishes by the specimens collected by the United States Fish Commission under Prof. Baird, I commenced an examination of all the specimens of the group which could be obtained. I have long known of the existence of a species of Liparis on the coast of Massachusetts, specimens having been collected as long ago as 1856 and exhibited at that time in the Aquarial Gardens of Boston. The same species was afterwards obtained by several persons during the winter months, and I have several times dredged it during the summer in Salem harbor, but it was not until my recent examination that I satisfied myself that we have two species of the genus Liparis on our coast which are identical with the two found on the northern coast of Europe. They are the *Liparis lineata* (*vulgaris*) and the *Liparis Montagui*. The former, *L. vulgaris*, which with Günther and Lütken I consider the same as the *lineatus* of Lepechin, is thus far only known, by me, from the American coast by specimens dredged by Dr. Packard and Prof. Verrill while connected with the U. S. Fish Commission. These were obtained in several localities off the New England coast at about fifty fathoms depth.* The *Liparis Montagui* appears to be the more common species on our New England coast, many specimens having been found in Port-

*Since the meeting of the Association I have obtained a specimen of the striped variety, collected in October, by Mr. J. H. Sears, in Salem harbor. This specimen was taken near Baker's Island in about six feet of water, and obtained by drawing up the kelp, to a root of which it was attached.

land harbor, Maine, by Mr. Chas. Fuller. Specimens have also been collected by Prof. Verrill at Eastport, Maine, and by Mr. Cutting, Mr. Sanborn, Mr. Alex. Agassiz and myself along the coast of Massachusetts, especially at Nahant and Salem. Dr. J. Bernard Gilpin has also sent me drawings of the same species collected at Halifax, Nova Scotia. Both species are mentioned as occurring in Greenland.

The external differences between the males and females of species of *Liparis* have not yet been pointed out, but on examining the large number of specimens of *L. Montagui* collected by Mr. Fuller at Portland in February or March, 1871, which were evidently spawning among the seaweed at the time, I found a marked difference between the sexes, the males being readily distinguished from the females by having the first six rays of the dorsal fin greatly prolonged and quite fleshy, while in the females the corresponding rays were not so produced. The males were also quite covered with granulations extending over the greater part of the body and on the dorsal and anal rays. I noticed that these granulations glistened like minute specks of silver and, on using a lens, they proved to be composed of very fine hair-like scales, which were easily detached; so that we have in this group something akin to the development of the granulations or tubercles on the head and fins of Catostomus, some Cyprinidæ and other fishes, during the time of greatest sexual development.

There seems to be the same diversity of coloration in *L. Montagui* as in *L. lineata* (*vulgaris*), as Mr. Fuller informs me that when alive, the specimens he collected were mottled and marbled with several colors, though in alcohol they are all of a uniform brownish color. In a large number of specimens of *L. lineata* kindly sent to me by Mr. T. J. Moore of the Liverpool Museum, which were collected on the coast of England, I found many specimens that were simply light brown, without markings of any kind, while others showed the longitudinal lines to a greater or less extent, which led Lepechin to name the species *lineatus*.

In regard to the affinities of the group generally known under the name of Discoboli, my investigations especially in regard to the osteological characters, lead me to assign the several representatives of the old group somewhat differently than has yet been proposed. Dr. Günther has already removed the Gobiesocidæ proper (*Gobiesox*, *Lepadogaster*, and their allies) from the group

and though Prof. Gill has, while considering them a distinct family, retained them as one of the three families of his group of Gobiesocoidæ, I should, with Günther, put the family of Gobiesocidæ far away, at least a suborder off, from the Cyclopteridæ and Liparididæ, which are far more closely united to the true Cottidæ, represented by *Cottus* and *Hemitripterus*, than to either the Gobiesocidæ proper or to the Gobies and Blennies. In fact *Liparis* has as close affinities, as shown by its skeleton, with *Cottus* and *Hemitripterus* as with *Cyclopterus*, and we have in the three groups, represented by Cottus, Liparis and Cyclopterus, well marked families of the same suborder. The only character by which the Cyclopteridæ and Liparididæ are closely united consists in the peculiar formation of the ventral disk by the union of the ventral fins, but as this structure is simply brought about by the modification of the rays in a manner common to the several genera and not by any marked anatomical difference in the structure of the same fins in Cottus, I can only look upon it as a generic character common to the known representatives of both families of Cyclopteridæ and Liparididæ, and the discovery of a representative of either family with ventral fins of the ordinary form would not necessitate the establishment of a family for its reception, as in that case we should simply consider the structure as of generic value.* The various modifications of the ventrals in the different genera of Gobiidæ confirm this view.

It is singular that Prof. Cope does not mention either Cyclopterus or Liparis in his recent classification, but from the characters he has given of his group Scyphobranchii, in which he includes the Uranoscopidæ, Gobiidæ, Blenniidæ, Gobiesocidæ, and Cottidæ, it is probable that he would have placed the families in the group had he not omitted to mention them. But while they would find their natural position here by the side of the Cottidæ I am not at present willing to admit any such close affinities between them and the other families there given.

The study of the large amount of material in my hands, for which I am especially indebted to Professor Agassiz, has enabled me to draw a few conclusions as to the characters assigned to the genera and species of Liparididæ, and among them I may state

* Under the name of Psychrolutes, Dr. Günther has described a peculiar fish which he considers as forming the type of a new family. Many of the characters given indicate its affinities to be with Liparis, as Dr. Günther states, though the ventrals are composed of but two rays each, and do not form a sucking disk.

that no generic, and hardly a specific value, can be placed on the character of the nostrils, for they are very nearly alike in all the species that have passed under my revision; neither is the character of the union of the dorsal and anal fins with the caudal of generic importance, as I find that there is no difference in the structure of the last vertebræ of the tail, and that even in *Liparis pulchellus*, which has the most eel-like tail of all externally, the skeleton shows the last vertebra with its expanded spines the same as in *L. Montagui*, where the caudal is more distinctly separated from the other fins. These differences are simply of a specific value and the slight variations are constant with each species. The union of the suborbital chain into one long bone reaching from the maxillary to the posterior edge of the preoperculum, and the long slender ray-like interoperculum overlying the branchiostegal rays are marked characters of the Liparididæ.

The geographical distribution of the two families of Cyclopteridæ and Liparididæ is very nearly the same and offers some interesting considerations. The following list gives the distribution of each of the, at present, recognized species of the two families. The localities from which I have seen specimens are indicated by an asterisk.

Cyclopterus lumpus.—Greenland (Me.,* Mass.*) to New York, Iceland,* England,* Northern Europe.

Cyclopterus spinosus.—Greenland to Eastport,* Me., Iceland, Spitzbergen.

Cyclopterus orbis.—Esquimault Harbor, N. W. C. of America.

Liparis Reinhardtii.—Greenland.

Liparis gelatinosus.—Kamtschatka.

Liparis callyodon.—Kamtschatka.

Liparis cyclopus.—Esquimault Harbor and San Francisco.*

Liparis pulchellus.—San Francisco.*

Liparis mucosus.—San Francisco.*

Liparis major.—Greenland.

Liparis arctica.—Greenland.

Liparis Fabricii.—Greenland, Spitzbergen.

Liparis lineata.—Greenland to Massachusetts,* Spitzbergen, Northern Europe, England.*

Liparis Montagui.—Greenland (Me.*) to Massachusetts,* Northern Europe, England.

Liparis Agassizii.† — Saghalien,* Channel of Tartary.

Liparis antarctica.‡ — Eden Harbor* (coast of New Chili, about latitude 48° south).

From this list it will be noticed that of the two families, five species are common to both sides of the North Atlantic Ocean, and that their limits are from the Arctic regions of Greenland, Iceland and Spitzbergen, south to about latitude 41° north on the American coast (New York, *Cyclopterus*) and to about 50° north on the European coast (British Channel, *Cyclopterus* and *Liparis*). Three other species are confined, as far as known, to the Greenland coast. In the North Pacific, two imperfectly known species have been described from the sea of Kamtschatka, and I have added another from the Channel of Tartary, while four other species are found on the northwest coast of America, extending only as far south as San Francisco (*Liparis*), or about latitude 37° north. But one species is as yet known from the southern hemisphere and that is from Eden Harbor, about latitude 48° south. Until this addition to our knowledge of the distribution of the group, which is one of the results of the recent Hassler expedition, it was supposed that the representatives of the two families were limited to the northern and temperate regions of the Atlantic and Pacific oceans. The newly discovered species is, however, true to the habits of the group, and comes from the cold waters of the extreme south, while no intermediate forms have yet been found in the wide space between Eden Harbor and San

† *Liparis Agassizii.* I have introduced this species into the list since the paper was read before the Association. Two specimens of this large and very distinct species were received by Professor Agassiz from Messrs. Peirce and Smith from Saghalien, Channel of Tartary. The species will be fully illustrated and described in Part I of the "Catalogue of the Agassiz Collection of Fishes," now in preparation, and I therefore simply indicate its characters here.

Total length, 10 inches. Head contained 4½ times in total length. Interobital space equal to distance from snout to posterior margin of the eye. Dorsal and anal united to the caudal. Anterior portion of dorsal and anal enclosed in the skin, so that only the rays of about the posterior half of each fin are seen without removing the skin. Rays, counted after taking off the skin, as follows: D. IX, 33; A. I, 33; P. 36; C. I, 10, I. Color brownish, with yellow and light mottlings.

‡ *Liparis antarctica.* This species will be fully illustrated and described in the "Catalogue of the Agassiz Collection of Fishes." It is represented by the single specimen obtained at Eden Harbor. Total length, 1¼ inches. The head is contained slightly more than four times in the total length, and equals the height and width of the body. The interorbital space is equal to the distance from the eye to point of the operculum. The dorsal and anal fins are covered by a thick skin anteriorly, the rays being distinctly seen only as they approach the caudal fin to which both dorsal and anal are united. Color in life was deep yellow; in alcohol it is of a uniform light brown.

Francisco, though it is probable that other species will be discovered in the cold waters of the South American coast. The representatives of the group are lovers of cold waters as shown not only by their distribution, but by their habits, for though in the more temperate countries where they are found, as on our own coast, they come to the shore in the cold winter months to leave their eggs, they afterwards retire to deeper and colder waters and in the summer have only been taken on the coast of Massachusetts and Maine by means of the dredge, which is now doing so much in the hands of careful observers in increasing our knowledge of animal life in all its forms.

In relation to the distribution of the Cyclopteridæ and Liparididæ it is interesting to note the distribution of the family of Gobiesocidæ, so long confounded with them, but now separated as a family not only removed from the others on structural grounds but also by its general distribution. While the Cyclopteridæ and Liparididæ have their greatest development in and towards the Arctic regions, the Gobiesocidæ have theirs in and towards the tropics, being found throughout the tropical and temperate regions of the Pacific and Atlantic, and having but one genus with one or two species only extending from the Mediterranean to the British and Scandinavian coasts.

Explorations of Casco Bay by the U. S. Fish Commission, in 1873. By A. E. Verrill, of New Haven, Conn.*

Since the appointment, in 1871, of Prof. S. F. Baird, U. S. Commissioner of fish and fisheries, he has considered it essential to investigate the invertebrate animals of our coast, with especial reference to their habits, distribution, and importance as food for fishes; to this end extensive dredging operations have been

*An abstract of this paper is published in the "American Journal of Science," vols. vi and vii, Dec., 1873 to Feb., 1874.

undertaken at his request, and with his coöperation, during the three summers, by the writer and several other volunteers, in connection with his investigation of the fishes and fisheries.

In 1871, our operations were carried on in Vineyard Sound and the adjacent waters. The results of the extended operations of that season have been published in the first official report of Professor Baird, with numerous illustrations. In 1872, the headquarters of the Fish Commission, with its large party of volunteers, were established at Eastport, Maine. The adjacent waters of the Bay of Fundy were pretty thoroughly examined with the dredge and other apparatus, and a very large collection was made. In the same year Mr. S. I. Smith, Mr. Oscar Harger, Dr. A. S. Packard and Mr. C. Cooke, made important dredgings in behalf of the Fish Commission, on Saint George's Bank, and in the deep waters to the north and east of that bank, and off the coast of Nova Scotia, while on the U. S. Coast Survey Steamer, "Bache." Preliminary accounts of the results of these explorations were published in the "American Journal of Science."

This year, the party, which has been quite large, located at Peak's Island. This island is situated at the entrance of Portland Harbor, and about four miles from the city. This has proved to be a very favorable locality, on account of its central position, allowing us to dredge in all parts of Casco Bay and the connected bays and fiords, and to visit any of the numerous islands for which Casco Bay is so famous, without too great loss of time; and to take advantage of favorable weather for longer trips to the deeper waters outside the bay. The littoral animals of the island itself, owing to the diversity of the shores and purity of the water, have also proved to be numerous and interesting.

The fishes and the investigations more immediately connected with the fisheries have been attended to by Prof. Baird, aided by his secretary, Mr. Rockwell, Prof. Theodore Gill, Dr. Edw. Palmer, Mr. G. Brown Goode, Mr. Spencer Biddle and others. The dredging operations, the examination of the food of fishes, and all investigations concerning the invertebrate animals generally, have been in charge of the writer and Mr. S. I. Smith, aided by Prof. Wm. N. Rice and Mr. Goode, of Wesleyan University; Prof. J. E. Todd, of Tabor College, Iowa; Prof. H. E. Nelson, of Ohio Wesleyan University; Mr. J. H. Emerton, Salem, Mass.; Mr. J. K. Thacher, of Yale College; Mr. Franklin Benner,

Astoria, N. Y.; and for a short time by Dr. P. P. Carpenter, of Montreal; Mr. C. B. Fuller, of Portland; Dr. J. B. Holder, of New York, and several others.*

Much of the success of the expedition is due to the interest taken in such scientific researches by Secretary Robeson, who caused a small U. S. steamer, the "Blue Light" to be specially fitted out for our dredging operations, under commander L. C. Beardsley, U. S. N. This steamer was provided with a steam windlass for hoisting the dredges and trawls, and with other conveniences, which greatly facilitated our operations, and enabled us to make much longer excursions to the outer waters and to do much more work during the summer, than otherwise would have been possible. Captain Beardsley has taken great interest in our investigations and has done all in his power to aid us in various ways. His constant endeavor has been to make the steamer as useful as possible to us. Our thanks are also due to Mr. Cooke, the executive officer, and to all the other officers and men for the hearty goodwill with which they have coöperated in our work and executed all our plans.

Ample wharf privileges were found at "Trefethen's Landing," and a building upon the wharf was speedily converted into a rather rude but comfortable laboratory. An excellent set of apparatus was provided by the Fish Commission, including a large assortment of dredges, rake-dredges, tangles, trawls, towing-nets, seines, sieves of various kinds, and all other kinds of apparatus and improvements which our past experience had proved useful or desirable. Sets of the apparatus such as were used by the English expeditions, on the "Porcupine" and "Challenger," were also imported by Prof. Baird, but were not found to offer any advantages over those which we had used in previous years.

* In consequence of the liberal coöperation of Prof. Pierce, superintendent of the U. S. Coast Survey, and other officers of the Survey, the U. S. Coast Survey steamer Bache was despatched, during the month of September, on several dredging expeditions to the deeper waters and distant banks off the coast of Maine, which we could not well reach with the "Blue Light." The dredges and other apparatus necessary for this work were provided by Prof. Baird, and the dredging on the "Bache" was under the superintendence of Dr. A. S. Packard, of the Peabody Academy of Science, Salem, Mass., aided by Mr. Caleb Cooke, also of the Peabody Academy. They were very successful in these explorations, and made several collections of great interest. A brief account of the results of their investigations has been published in the "American Journal of Science," for April and May, by the writer. Another account of these expeditions was published in the "American Naturalist," vol. viii, p. 145, March, 1874, by Dr. Packard.

The English "accumulator" we found no occasion to use in our work, for a simple "check-stop," devised by Capt. Beardsley, proved equally efficient and far more convenient and simple, as well as quite inexpensive.* This was found to answer every purpose in dredging or trawling at all depths down to 100 fathoms, and undoubtedly would do equally well at far greater depths. With a larger vessel, in heavy weather, or at very great depths, the rubber accumulator would doubtless prove advantageous, but it is quite superfluous for working in less than 500 fathoms, in moderate weather. Therefore, any party undertaking such dredgings as can be carried on with small vessels off our coast, need not encumber themselves with this expensive piece of apparatus, for which a few fathoms of small or weak rope, applied in the form of a "check-stop," may be substituted.

Deep-sea thermometers, water-bottles for obtaining samples of the bottom-waters, and other physical apparatus, were also provided and frequently used.

Mr. Emerton was employed to make drawings of the more interesting new and rare animals, from life. These drawings are remarkably accurate and life-like, and number nearly three hundred. They constitute one of the most valuable results of the expedition. As Mr. Emerton had drawn large numbers of our common marine animals for us during the two previous years, a considerable portion of his time has been devoted during this season to the free-swimming larval stages of crustacea, etc., and to the smaller and less known species in various classes. The soft parts of many species of mollusks have also been well figured. To Mr. S. I. Smith I am specially indebted for the identification of most of the crustacea mentioned in this article, and for other assistance.

Much attention was paid to the determination of the temperature of the water, both at the surface and bottom, in many of the localities where dredgings were made. The more important of these are given in the following tables.

* This arrangement and the dredges, tangles, trawls, rakes and other apparatus used by us, were described and illustrated in several letters to the New York Tribune by Mr. Wm. C. Wyckoff, one of the editors, who spent some time with us at the island, and accompanied us on several excursions. These letters are brought together in the "Tribune Extra," No. 10, Scientific Series, in connection with the daily reports of the meetings of the association.

TEMPERATURES TAKEN IN AND NEAR CASCO BAY, IN FIVE TO SEVENTY-FIVE FATHOMS.

Date	Locality.	Weather.	Hour.	Tide.	Temperature. F. Air.	Surface.	Bottom.	Depth in fathoms.	Nature of bottom.
July									
21	Off Cape Elizabeth.		12 M.	2 h. ebb		51°	44¾°	24	Gravelly.
22	Off Upper Flag I.	Clear	11 A.M.	1 "		57	50	16	Sandy.
"	Broad Sound.	"	1 P.M.	3 "		52	48	34	Gravel.
24	Luckse's Sound.	"	10.40 A.M.	5 h. flood	80°	56½	46½	12½	Muddy.
"	Broad Sound.	L.Cl'ds	12.10 P.M.	1 h. ebb	84	62	49½	16½	Fine sand.
"	Off Eagle Island.	"	2 P.M.	3 "	80	65	45½	31	Gravel.
26	Broad Sound.	Clear	11 A.M.	5 h. flood	68	56½	47½	16½	Sand.
28	Off Fort Gorges.				65	59	52	11½	Muddy.
30	Broad Sound.				67	60	49½	22	Gravel & sand.
"	" "				66	60	53	9½	Gravel.
"	" "				66	60	53	17	Sand & shells.
31	Off Portland Light.	Cloudy	5 P.M.	1 h. ebb	69	59½	49½	13½	Sandy.
Aug.									
2	Off Crotch Island.	"	11.35 A.M.	l. w. slack	71	61	47	11	Muddy.
"	Mericoneag Sound.		0.50 P.M.	1 h. flood	69	63½	45	12½	"
"	Near Cow Island.	"	2.30 P.M.	3 "	67	62	54½	9	Gravel.
4	N. E. of Cow Island.	Clear	10.25 A.M.	3 h. ebb	70	65	51	12	"
"	Near Inner Green I.	"	11.40 A.M.	4½ "	73	63	48½	12½	"
"	Off Halfway Rock.	"	11.55 A.M.	5 "	75	62	46½	19	Sandy.
"	Off Eagle Island.	"	1.30 P.M.	l. w. slack	74	60	43½	18½	Gravel.
5	West Cod Ledge.	"	11.15 A.M.		72	64	46	13	Sand & rocks.
"	15 m. off C. Elizabeth.	"	2.00 P.M.		65	64	39½	48	Muddy.
6	14 " " "	"	12.00 M.		69	64	38	54½	"
"	15 " " "	"	3.00 P.M.		72	64	37½	48	Mud & rocks.
"	17 " " "	L.Cl'ds	4.15 P.M.		68½	65	36	64	Muddy.
7	Chambers' Cove.	Cloudy	2.20 P.M.	4 h. ebb	70	59	54	7	"
11	Broad Sound.	Clear	12.00 M.	4 h. flood	65	57	47½	25	Gravel.
"	Luckse's Sound.	"	2.20 P.M.	h. w. slack	65	55½	45	15	Muddy.
12	West Cod Ledge.	"	10.00 A.M.		63	61	47	13	Sandy.
"	20 m. off C. Elizabeth.	"	0.45 P.M.		64	62½	38	68	Muddy.
13	West of Seguin Island.	"	11.00 A.M.	1 h. flood	64	52	47	12	Sandy.
"	6 m. E.S.E. of Seguin I.	L.Cl'ds	0.35 P.M.	2½ "	64	57	41½	33	Sand & rocks.
14	Main channel.	Cloudy	12.15 P.M.		62	57	55½	9	Muddy.
"	Off Clapboard Island.		1.10 P.M.		64	55½	54	9	"
20	9 m. S.S.E. of Seguin I.	"	11.35 A.M.		62	59	38	75	"
"	5 m. S. E. of Seguin I.	"	1.40 P.M.		65	58	38½	40	Sand & gravel.
Sept.									
1	Off Witch Rock.	"	11.00 A.M.	5 h. ebb	58	54	50½	14	Rocky.
3	Off Pole I., Quahog B.	Clear	11.45 A.M.	4½ "	63	59½	53	5	Muddy.
"	" " "	"	12.15 A.M.	5 "	63	59	54½	6	"

FAUNA OF THE OUTER WATERS ON MUDDY BOTTOMS.

One of the most interesting regions examined was in the deeper waters outside of Casco Bay, 15 to 30 miles southeast from Cape Elizabeth. To this region we made several excursions, and dredged at depths varying from 40 to 95 fathoms, the depth gradually increasing with the distance from the shore. In these localities the bottom was generally of soft mud, with more or less numerous, scattered bowlders. On one occasion we brought up in the trawl from 65 fathoms an angular bowlder, estimated to weigh over 500 lbs. These bowlders were probably transported from the adjacent coast by shore-ice in spring. They were usually covered with sponges, bryozoa, ascidians, hydroids, *Terebratulina*, etc. The bottom temperature of these waters was remarkably low, varying from 36° to 40° F., while the surface was usually between 60° and 65°, or even higher. The temperatures obtained here are quite as low as those that we obtained in the deeper parts of the Bay of Fundy last year, and the fauna proved to be correspondingly arctic in character, and agrees pretty closely with that at the mouth of the Bay of Fundy, and also with the dredgings made last year, in 85 to 150 fathoms, near St. George's Bank. In fact, these three regions may be regarded as distant parts of one great basin, referred to in a former article as "St. George's Gulf," but named "Gulf of Maine" on some of the Coast Survey charts, and this region is throughout its whole extent bathed in cold water of nearly uniform temperature, at corresponding depths. The deepest parts of this gulf seldom exceed 150 fathoms, and are perhaps nowhere more than 200 fathoms deep. Whether the nearly ice-cold water filling the deeper parts of this cold area can be regarded as constituting a definite current, or offshoot from the great arctic current, flowing southward along our coast in deep water off shore, or whether it be a portion of the great body of cold water filling the ocean basin at great depths, which is brought into this partially closed basin by the powerful tidal currents, is still uncertain. But it is important to have established the fact that this body of cold water approaches so closely to the coast of Maine as to manifest itself most distinctly within 12 or 15 miles of Cape Elizabeth, both by its highly arctic fauna and its icy temperature, even in midsummer. Moreover, there can be no doubt but that the con-

stant admixture of this cold bottom water with the warmer surface waters, by means of the strong tides and local wind currents, causes the remarkably low temperatures observed, both at the surface and bottom, in the shallow waters of these shores,* and even in the smaller bays and harbors along the entire eastern and northern coasts of New England. The surface water in Casco Bay, among the islands, where the water is quite shallow, was usually found to be colder than it was on the same days, outside the bay, where the water was deep. It is also evident that a strong wind blowing from the shore for some time will have the effect to cause an ascending current of cold water along the submerged slope of the shore, to supply the place of the surface-water driven seaward by the wind; while an easterly wind will force the warmer surface water toward the shore, and cause a descending current along the slope, partially forcing the cold water away from the shallows. Our observations, both in Vineyard Sound and Casco Bay, show that such an action does take place, and that the temperature of the water near the shore is rapidly lowered by a westerly or off shore wind, and is as quickly raised by an easterly wind, independently of the temperature of the air.† But the effect is often somewhat masked, in summer, by reason of the much higher temperature of the westerly winds, which quickly warm the water close to the surface. Observations made early in the morning, before the effect of the direct heat of the sun becomes apparent, are the best for detecting the influence of tidal and wind currents.

Among the species obtained on these bottoms, in 50 to 94 fathoms, were several fishes, among which *Raia lævis*, *Sebastes viviparus*, *Pomatopsetta dentata*, and a species of *Phycis* were the most common. Among the more interesting Crustacea were numerous large and fine specimens of the rare *Pandalus borealis*, some of which were eight or ten inches long, dredged in several localities in 50 to 68 fathoms; *Sabinea septemcarinata*, a rare shrimp, dredged in 68 fathoms, and not obtained before on our coast, except in the deeper parts of the Bay of Fundy; *Byblis Gaimardii*

* The temperature of the bottom-waters in the deeper channels among the islands, in 15 to 25 fathoms, was usually from 42° to 52° F.; while the surface was usually between 52° and 62° in July and August.

† See the Report of the U. S. Fish Commission for 1871, p. 436, for a fuller discussion of this subject by the writer. Rev. J. W. Chickering also informs me that he has made series of observations at Hampton Beach, N. H., which establish such a coincidence. The change sometimes amounts to 10° F. in a few hours.

and numerous other Amphipods; two species of Lernæans, parasitic on Annelides, etc. The Annelides were very numerous, and among them were many rare and interesting species, some of which were undescribed, and others new to our coast. Among the more interesting of the Annelides, are *Eunoa nodosa* Malmgren, which was dredged in 68 fathoms, and subsequently by Dr. Packard on Jeffrey's Ledge in 33 fathoms. It differs from the more common *E. Œrstedii*, in its broader body, with broadly reniform scales, on which there are only a few rounded tubercles, near the margin; *Lœtmonice filicornis*, a large, oblong, scaly worm, allied to *Aphrodita*, but with the large thin scales more or less exposed, with fewer and stouter setæ, and with long slender antennæ; *Antinoë Sarsii*, a scaly worm with long slender setæ in the lower rami; *Enipo gracilis* V. (Plate 5, fig. 3), a new and very slender species of scaly worms; *Nephthys ingens* Stimpson (Plate 2, fig. 2), which is very common on all the muddy bottoms along the whole New England coast, in 5 to 150 fathoms. It is easily distinguished not only by the peculiar head and proboscis, but by the wide separation and great elongation of the upper and lower rami on the posterior half of the body, by the squarish form of the body posteriorly, and by the blackish color of the setæ. *Ninoë nigripes* V. (Plate 3, fig. 5), *Goniada maculata*, *Anthostoma acutum* V., *Chætozone setosa* Malmgren, *Ammotrypane fimbriata* V. (Plate 2, fig. 3), *Notomastus latericeus* Sars, and several species of *Amphitrite*, were frequently met with; *Nothria opalina* V. (Plate 4, fig. 4), *Pista cristata* Malmgren, *Melinna cristata* M., and *Terebellides Stroemi* were common on all the deep-water muddy bottoms. *Grymæa spiralis* V. (Plate 5, fig. 5), a new species remarkable for its curious tube, composed of sand firmly cemented in the form of a double spiral, the two halves coiling in opposite directions, occurred in both 64 and 94 fathoms, and had previously been dredged by us in the Bay of Fundy, off Grand Menan. *Rhodine Loveni* Malmgren, and *Axiothea catenula* M., are new additions to the American fauna. Among the Sipunculoid worms *Phascolosoma cœmentarium* and *P. tubicola* V. were common; *P. boreale?* was rather rare in 64 fathoms, but was afterwards dredged in abundance on Cashe's Ledge by Dr. Packard; *Chætoderma nitidulum* Loven (Plate 6, fig. 6) was not uncommon in 48 to 64 fathoms.

A remarkable new genus of Nemerteans, was represented by a

specimen eight feet long, of a bright orange color. This is the *Macronemertes gigantea* V. (Plate 2, figs. 5, 6). Among the mollusks there were many interesting species, though but few that were new to our coast. *Crenella decussata*, apparently perfectly identical with European specimens, and very distinct from *C. glandula*, was not rare. *Neæra arctica* Loven, of large size, occurred sparingly in most of the deeper dredgings. *Yoldia thraciformis* was common in all the deeper localities, and some of the living specimens were unusually large. *Arca pectunculoides* and *Dacrydium vitreum* occurred in the 94-fathom locality, about thirty miles off Cape Elizabeth; the last is a new addition to the fauna of the United States. *Scaphander puncto-striatus*, of good size, and *Philine quadrata* were not uncommon in most of the deeper hauls. *Dentalium occidentale* occurred in the 94-fathom locality, and with it a species occurred which much resembles *Entalis striolata*, but in the character of the animal (see Plate 1, fig. 3) it agrees better with the *Dentalium agile* of G. O. Sars. *Aporrhais occidentalis*, *Neptunea curta* (Jeff. sp.), *N. pygmæa* (Gould sp.),* *Turritella erosa*, *Pecten Islandicus*, and many other decidedly northern shells were not uncommon. *Octopus Bairdii* V. (Plate 1, figs. 1 and 2) occurred only once, in 68 fathoms; it had been dredged previously only in the deeper parts of the Bay of Fundy, in 1872. Among the Ascidians were fine specimens of *Glandula fibrosa* Stimpson, and *Eugyra pilularis* V.; a large, soft and rather flabby species, *Ascidia mollis* V. (Plate 1, fig. 5), occurred in abundance, associated with several other more common species. A bright purple *Botryllus* was once met with in 64 fathoms. On the scattered bowlders there were several fine species of Bryozoa, such as *Flustra solida* Stimpson, *Tubulipora crates* Stimpson, etc., associated with very large specimens of *Terebratulina septentrionalis*, and numerous sponges.

Of Echinoderms the most abundant species was the starfish, *Ctenodiscus crispatus*, of which we obtained about a thousand in

* An examination of the dentition of this and the preceding species shows that they are true Buccinidæ, and quite different from the *Tritonium Islandicum* of Loven (= *Fusus Berniciensis*, t. Jeffreys), which has been regarded as the type of *Sipho*. Our American shell, usually called *Islandicus*, but which has been named *Fusus curtus* by Jeffreys, is a genuine *Neptunea* closely allied to *N. despecta*, etc. The *pygmæa* differs considerably in its dentition from the typical forms of *Neptunea*, as well as in having a woolly epidermis, and ought to be separated as a distinct genus, or subgenus, which I have elsewhere described under the name of *Neptunella*. (See Report of U. S. Fish Commission, for 1871, p. 639).

one haul with the trawl, but *Ophioglypha Sarsii* and *O. robusta* were also abundant; the little Ophiuran, *Amphipholis tenuispina* Ljung., occurred in 68 fathoms; this is a new addition to the American fauna; *Hippasteria phrygiana* occurred twice; *Ophiacantha spinulosa* and *Schizaster fragilis* were not rare; *Thyone scabra* V., *Molpadia oölitica* and several other interesting species also occurred; *Corymorpha pendula* was abundant in 95 fathoms; among the Anthozoa were *Cerianthus borealis* V., *Edwardsia farinacea* V., *Urticina nodosa* Fabr. sp. (=? *Tealia digitata* Gosse),* *Bolocera Tuediæ* Gosse, very large and fine. The last species had not been known from the American coast before, except from a few detached tentacles dredged last year near St. George's Bank, and *U. nodosa* had not been previously found, except last year, when it was dredged by Mr. Smith, east of St. George's Bank, in 430 fathoms, and by Mr. Whiteaves in the deeper parts of the Gulf of St. Lawrence. The specimens obtained this year are much larger, some of them being 6 inches high and 4 in diameter. Of sponges, several very interesting species occurred; among them a large specimen, two feet broad, of *Phakellia ventilabrum* Gray (the *Halichondria ventilabrum* of the earlier English writers); a species apparently belonging to the genus *Trichostemma* of G. O. Sars; and over twenty specimens of *Hyalonema longissimum* M. Sars, some of them of unusually large size; these were all obtained in 95 fathoms, about 30 miles east-southeast from Cape Elizabeth. This last species had not been dredged before on the American coast, with the exception of a single specimen dredged last year by Messrs. Smith and Harger, off St. George's Bank, in 430 fathoms.†

With the *Hyalonema* an allied species often occurred, consisting of small irregular, elongated, fusiform, compact, white sponge-masses, connected by capillary stolon-like stems, made up of slender spicules twisted together. This species creeps over the bottom, but does not stand erect, like the former.

Several calcareous sponges were also met with; among these was a large and handsome species of *Grantia*, externally hispid,

*It seems to me very doubtful whether the *Actinia digitata* of Müller was actually the species that commonly bears that name in recent European works. The description would apply better to the *Bolocera Tuediæ* of Gosse. The species referred to above is certainly the *A. nodosa* of Fabricius, who well described it in 1780, as from deep water off the Greenland coast.

†Mr. Whiteaves writes me that he has also dredged it in the Gulf of St. Lawrence this summer; and it was also subsequently obtained by Dr. Packard.

with long slender spicula, and with an elegant crown of very long spicules around the terminal orifice. It most resembles *G. arctica* (*Sycandra arctica* Hæckel), but may be an undescribed species.

At another locality, about nine miles south-southeast from Seguin Island, in 75 fathoms, the same kind of bottom was found and the fauna was nearly identical with that described above.

At this place the finest specimen yet observed of *Cerianthus borealis* V. was obtained in good condition, and was kept alive several days, until a colored drawing could be made by Mr. Emerton. This specimen, in extension, was about 20 inches long, and the expanse of its tentacles was over six inches. The color of its body was deep olive-brown. This species was not discovered until last year, but it was met with at several different localities this year, and seems to be not uncommon on muddy bottoms in 20 to 100 fathoms, though seldom obtained of full size by the dredge, owing to its living deeply buried.

LIST OF SPECIES FROM OFF CASCO BAY, MAINE, INHABITING MUDDY BOTTOMS, IN 50 TO 95 FATHOMS.

In the following list the species with an asterisk (*) prefixed belong more properly to the hard bottoms, but occur more or less frequently on the muddy bottoms, adhering to scattered stones, or among broken shells.

The figures affixed to the names give, in fathoms, the greatest depths at which the species have been dredged on the New England coast.

ARTICULATA.

Pycnogonida.

Nymphon giganteum, 82.
*N. grossipes (?), 65.

Crustacea.

*Hyas araneus, 72.
*H. coarctatus, 150.
*Eupagurus pubescens, 150.
*E. Kroyeri, 430.
*E. Bernhardus, 150.
*Hippolyte spina, 72.
*H. Fabricii, 64.
Pandalus borealis, 68, 114.
*P. annulicornis, 430.
Sabinea septemcarinata, 68.
Thysanopoda, large sp., 142, 430.
Mysis, sp., 68.
Diastylis quadrispinosa, 68.
*Paramphithoë cataphracta.
Harpina fusiformis, 110.
Phoxus Kroyeri, 60.
Œdiceros lynceus, 90.
*Melita dentata, 430.
Byblis Gaimardi, 79.
Haploops, sp., 105, 114.
Ampelisca, sp., 142.
Ptilocheirus pinguis, 150.
*Unciola irrorata, 430.
Dulichia, sp., 60.
*Caprella, sp. with spines, 142.
Praniza cerina, 68.
Asellodes alta, 90.
Anthura brachiata, 110.
Lernæan, on Eunoa Œrstedii, 68.
Lernæan, on Terebellides Stroemi, 68.
*Balanus porcatus, 150.

Annelida.

Aphrodita aculeata, 72, 90.
Lætmonice filicornis, 150.
*Eunoa Œrstedii, 72.
*E. nodosa, 68.
*Harmothoë imbricata, 64.
Antinoë Sarsii, 110.
Enipo gracilis V., 80.
Pholoë minuta, 68.
Nephthys ingens, 142.
N. ciliata, 114.
Phyllodoce, sp., 110.
*P. Grœnlandica, 90.
Eteone depressa, 110.
*Nereis pelagica, 142.
Nereis, sp. 68.
Gattiola, sp. 68, 90.
*Leodice vivida, 430.
Nothria opalina, 150.
*N. conchylega, 430.
Ninoë nigripes, 114.
Lumbriconereis fragilis, 430.
Goniada maculata, 150.
Rhynchobolus albus, 110.
Scalibregma inflatum, 150.
*Travisia, sp., 95, 106.
Brada, sp., 90.
Tecturella flaccida, 90.
Trophonia aspera, 150.
Ophelia, sp., 107.
Ammotrypane fimbriata, 114.
Sternaspis fossor, 142.
Scolecolepis cirrata, 150.
Anthostoma acutum V., 64.
Anthostoma, sp.·
Chætozone setosa, 106.
*Dodecacerea concharum, 90.
Maldane Sarsii, 150.
Rhodine Loveni, 50.
Axiothea catenula, 54.
Praxilla gracilis, 114.
P. prætermissa, 114.
*Nicomache lumbricalis, 110.
Ammochares, sp., 142.
Notomastus latericeus, 110.
Ancistria capillaris V., 117
*Cistenides granulatus, 90.
Ampharete gracilis, 106.
A. Finmarchica, 110.
Amphicteis Gunneri, 110.
Amage auricula, 150.
Samytha sexcirrata, 110.
Melinna cristata, 150.
Terebellides Strœmi, 142.
Pista cristata, 150.
Grymæa spiralis V., 95.
*Thelepus cincinnatus, 142.
*Amphitrite cirrata, 95.
A. Johnstoni, 64.
A. Grœnlandica, 68.
A. intermedia, 94.
Polycirrus, sp., 110.
*Potamilla oculifera, 90.
Sabella zonalis, 107.
Chone, sp., 95.
Euchone elegans V., 106.
Myxicola Steenstrupii, 72.
*Protula media, 90.
*Vermilia serrula, 106.
*Spirorbis lucidus, 114.
Ichthyobdella (on Raia lævis), 68.

Gephyrea.

*Phascolosoma boreale (?), 64, 90.
P. cæmentarium, 430.
P. tubicola V., 110.
Priapulus, sp., 60.
Chætoderma nitidulum, 110.

Turbellaria.

Nemertes affinis, 110.
Meckelia lurida V., 110.
Macronemertes gigantea V., 68.
Ophionemertes agilis V., 90.

MOLLUSCA.

Cephalopoda.

Octopus Bairdii V., 106.

Gastropoda.

Bela decussata, 64.
B. cancellata, 430.
B. pleurotomaria, 107.
B. turricula, 117.
Admete viridula, 150.
Neptunea curta, 68.
N. decemcostata, 107.
Neptunella pygmæa, 430.
Buccinum undatum, 52.
Natica clausa, 430.
Lunatia Grœnlandica, 430.
L. immaculata, 430.
*Trichotropis borealis, 80.
*Velutina zonata, 150.
*V. lævigata, 110.
Aporrhais occidentalis, 150.
Turritella erosa, 106.
Scalaria Grœnlandica, 85.
Rissoa exarata, 95.
*Margarita obscura, 430.
*M. cinerea, 150.
*Calliostoma occidentale, 82.
*Diadora noachina, 430.
*Lepeta cæca, 110.
Scaphander puncto-striatus, 150.
Cylichna alba, 150.
Utriculus pertenuis, 114.
Philine quadrata, 110.
P. lineolata, 64.
*Polycera Lessoni, 50.
*Doris planulata, 142.
*Trachydermon albus, 150.
Stimpsoniella Emersonii, 60.
*Hanleia mendicaria, 80.
Dentalium occidentale, 150.
Entalis striolata, 150.
E. agilis ?, 95.

Lamellibranchiata.

*Zirphæa crispata, 80.
Mya arenaria (young), 64.
Neæra arctica, 150.
N. pellucida, 142.
*Saxicava arctica, 114.
Panopæa Norvegica, 115, 118.
Thracia myopsis, 150.
T. truncata.
Periploma papyracea, 109.
Macoma sabulosa, 142.
Cyprina Islandica, 72.
Cardium pinnulatum, 150.
C. Islandicum, 117.
Cryptodon Gouldii, 110.
C. obesus, 430.
Lucina filosa, 142.
Astarte lens, 430.
A. undata, 117.
A. quadrans, 150.
Cyclocardia borealis, 107.
C. Novangliæ, 90.
Nucula tenuis, 142.
N. proxima, 60.
N. delphinodonta, 68.
Leda tenuisulcata, 150.
Yoldia obesa, 150.
Y. thraciformis, 142.
Y. sapotilla, 117.
*Arca pectunculoides, 150.
*Modiolaria nigra, 107.
*M. discors, 90.
M. corrugata, 105.
Crenella glandula, 110.
C. decussata, 60.
Dacrydium vitreum, 95, 107, 142.
*Pecten Islandicus, 114.
*P. tenuicostatus, 110.
*Anomia aculeata, 150.

Tunicata.

*Ascidia mollis V., 107.
*Ascidiopsis complanatus, 110.
*Ciona tenella, 64.
Molgula pannosa, 64.
*M. retortiformis, 68.
Eugyra pilularis, 105, 114.
Glandula fibrosa, 95, 106.
*G. arenicola, 150.
*Cynthia echinata, 64, 80.
*C. carnea, 64, 80.
*Botryllus, sp., 64.
*Amarœcium glabrum, 64.
*Leptoclinum albidum, 72.

Brachiopoda.

*Terebratulina septentrionalis, 150.

Plate 1.

Fig. 3.

Fig. 1.

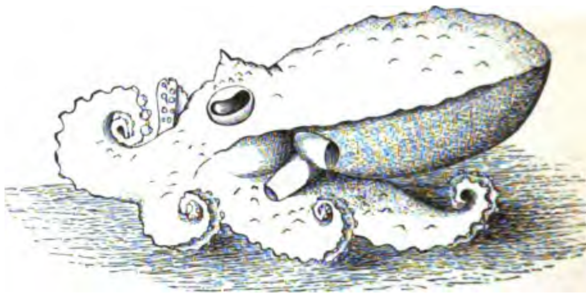


Fig. 4.

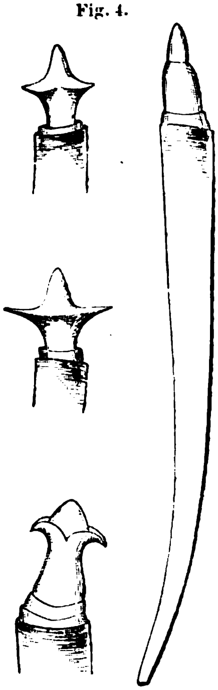


Fig. 2.

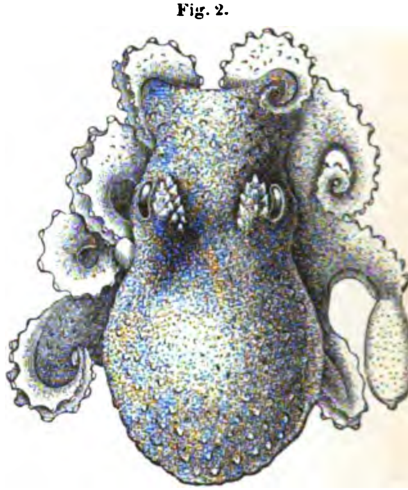


Fig. 5.

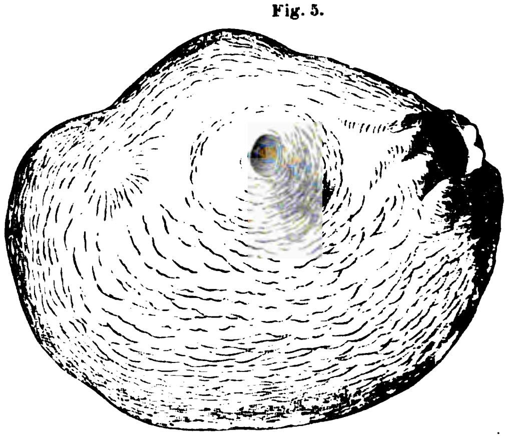


Fig. 6.

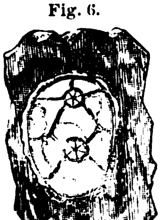


Plate 2.

Fig. 1.

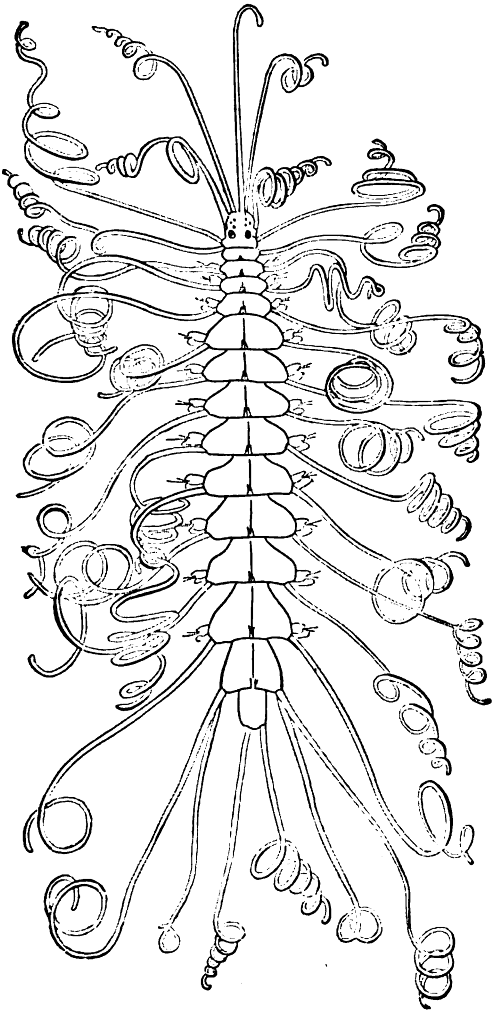


Fig. 2.

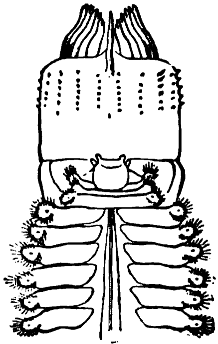


Fig. 3.

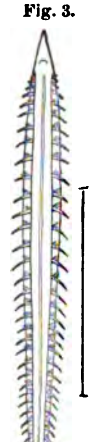


Fig. 4.

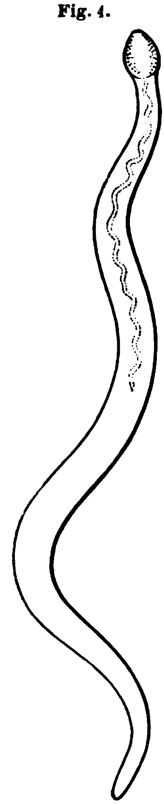


Fig. 5.

Fig. 6.

Fig. 7.

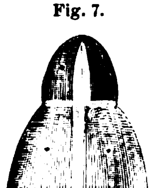
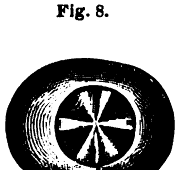


Fig. 8.



Polyzoa.

*Crisia eburnea, 117.
*Hornera lichenoides, 150.
*Discoporella verrucaria, 150.
*Idmonea pruinosa, 118.
*Discofascigera lucernaria, 110.
*Flustra solida St., 64.
*Membranipora pilosa, 64.
Gemellaria loricata, 142.
*Cellularia ternata, 150.
*C. scabra, 95.
C. Peachii (?), 150.
Bugula, soft sp., 95, 430.
*B. fastigiata, 150.
Bugula Murrayana, 430.
Caberea Ellisii, 150.
*Anarthropora borealis, 150.
*Cellepora scabra, 150.
*C. ramulosa, var., 150.
*Alcyonidium, sp., 64.

RADIATA.

Echinodermata.

*Lophothuria Fabricii, 110.
*Psolus phantapus, 72.
Pentacta assimilis, 95, 430.
Thyone scabra V., 110, 150.
Stereoderma unisemita, 142.
*Thyonidium productum, 80.
*T. hyalinum, 80.
Molpadia oölitica, 95.
Schizaster fragilis, 430.
*Echinarachnius parma, 430.
*Strongylocentrotus Dröbachiensis, 430.
*Leptasterias compta, 90.
*L. tenera, 65, 142.
*Cribrella sanguinolenta, 90.
*Hippasteria phrygiana, 60, 90.
Ctenodiscus crispatus, 114.
Ophioglypha Sarsii, 430.
O. robusta, 118.
O. affinis, 105, 118, 150.
*Amphipholis elegans, 105.
A. tenuispina, 105.
*Ophiopholis aculeata, 104.
Ophiacantha spinulosa, 150.

Acalephæ.

*Campanularia verticillata, 430.
*Sertularia cupressina, 150.
*Sertularella polyzonias, var., 142.
*S. tricuspidata, 430.
*Lafoëa gracillima, 430.
*Eudendrium ramosum, 430.
*Tubularia indivisa, 430.
Corymorpha pendula, 95.

Anthozoa.

*Cornulariella modesta V., 106.
*Urticina nodosa (Fab. sp.), 430.
*U. crassicornis, 430.
*Bolocera Tuediæ, 150.
Edwardsia farinacea V., 95.
E. sipunculoides, 106.
Cerianthus borealis V., 150.

PROTOZOA (*Spongiæ*).

*Grantia arctica (?), 95.
Hyalonema longissimum, 95.
*Polymastia sp., 117.
*Phakellia ventilabrum, 68.
*Reniera, soft sp., etc.

FAUNA OF THE HARD BOTTOMS IN THE OUTER WATERS.

Very few localities of "hard" bottom have been met with in more than 25 fathoms of water; and consequently we have not

obtained so complete a knowledge of the fauna occupying such bottoms, at greater depths off this coast, as of that inhabiting the soft muddy bottoms.* But a considerable number of species belonging properly on rocky bottoms came up attached to the bowlders, already referred to, which we frequently brought up even from the softest mud. Other inhabitants of such bottoms were obtained from the stomachs of fishes, freshly caught. From these and other sources we can now compile a pretty full list of species belonging to the hard bottoms in depths between 50 and 125 fathoms, off the coast between Cape Cod and Mount Desert.

Two of our dredgings, off Seguin Island, in 33 and 45 fathoms respectively, belong to the series of outer and deeper dredgings, rather than among those made in the bays. They are, however, somewhat intermediate in character.

The first named locality was unusually rich in species. I therefore give the entire list obtained at that place, so far as they have been identified. The bottom was generally hard, and in places rocky, but some patches of mud were evidently encountered by the dredge, and consequently there was a considerable number of true mud-dwelling species mixed with those belonging to the hard bottoms. Only one haul of the dredge was made at this locality, owing to unfavorable weather, but over 125 species of animals were obtained.

CONTENTS OF A SINGLE HAUL OF THE DREDGE MADE AUG. 13, 1873, ON HARD BOTTOM, WITH SOME SPOTS OF MUD, IN 33 FATHOMS; LOCALITY, SIX MILES EAST OF SEGUIN ISLAND.

ARTICULATA.

Pycnogonida.

Nymphon, sp.

Crustacea.

Hyas coarctatus.	Hippolyte spina.	Metopa, sp.
Eupagurus Kroyeri.	Unciola irrorata.	Caprella, sp.
Pandalus annulicornis.	Cerapus rubricornis.	Praniza cerina.
Hippolyte pusiola.	Monoculodes, sp.	

* This has, however, been remedied to a considerable extent by some of the subsequent dredgings made by Dr. Packard, when on the Bache.

Annelida.

Harmothoë imbricata.
Phyllodoce catenula V.
Nothria conchilega.
Lumbriconereis fragilis
Ninoë nigripes V.
Anthostoma acutum V.
Gattiola, sp.
Nereis pelagica.
Nicomache lumbricalis.
Ancistria capillaris V.
Cistenides granulatus.
Ampharete gracilis.
Ampharete, sp.
Melinna cristata.
Thelepus cincinnatus.
Amphitrite Grœnlandica
Scione lobata.
Chone, sp.
Potamilla oculifera.
Sabella, sp.
Spirorbis lucidus.
Vermilia serrula.

Gephyrea.

Phascolosoma cæmentarium.
Phascolosoma tubicola V.

Turbellaria.

Nemertes affinis.

MOLLUSCA.

Gastropoda.

Admete viridula.
Bela turricula.
Bela harpularia.
Bela violacea.
Buccinum undatum.
Neptunea decemcostata
Neptunella pygmæa.
Astyris zonalis V.
Trichotropis borealis.
Aporrhais occidentalis.
Velutina lævigata.
Lamellaria perspicua.
Lunatia Grœnlandica.
Turritella erosa.
Lepeta cæca.
Calliostoma occidentale
Margarita cinerea.
Diadora noachina.
Doris planulata.
Hanleia mendicaria Carp
Entalis striolata.

Lamellibranchiata.

Saxicava arctica.
Macoma sabulosa.
Cardium Islandicum.
Cardium pinnulatum.
Cyprina Islandica.
Astarte undata.
Astarte elliptica.
Astarte lens.
Cyclocardia borealis.
Crenella glandula.
Modiolaria discors.
Modiolaria corrugata.
Leda tenuisulcata.
Nucula tenuis.
Pecten Islandicus.
Anomia aculeata.

Tunicata.

Ascidiopsis complanatus.
Glandula arenicola.
Molgula pannosa.
Leptoclinum luteolum.
Leptoclinum albidum.
Amarœcium glabrum.
Lissoclinum, sp.

Brachiopoda.

Terebratulina septentrionalis.

Polyzoa.

Tubulipora crates.
Idmonea pruinosa.
Discofascigera lucernaria.
Crisia eburnea.
Caberea Ellisii.
Gemellaria loricata.
Flustra solida.
Cellularia ternata.
Cellepora scabra.
Cellepora ramulosa.

RADIATA.

Echinodermata.

Lophothuria Fabricii.	Stephanasterias albula Verrill.	Amphipholis elegans.
Strongylocentrotus Dröbachiensis.	Leptasterias compta.	Ophiopholis aculeata.
Solaster endeca.	Cribrella sanguinolenta.	Ophioglypha Sarsii.
Asterias vulgaris.	Ophiacantha spinulosa.	Ophioglypha robusta.

Acalephæ.

Lafoëa fruticosa.	Grammaria abietina.	Sertularella polyzonias.
Lafoëa dumosa.	Sertularia argentea.	Eudendrium capillare.
Halecium muricatum.	Sertularia latiuscula.	

Anthozoa.

Urticina crassicornis.	Cornulariella modesta V., new genus and sp.

PROTOZOA.

Spongiæ.

Tethya hispida.	Reniera, sp.	Grantia ciliata.
Halichondria, several sp		

Foraminifera.

Numerous species.

ALGÆ.

Laminaria longicruris.	Agarum Turneri.	Desmarestia aculeata.

The 45 fathom locality was about five miles southwest from Seguin Island. At this place we dredged many of the species obtained at the place last named, together with a number of additional ones, among which were the following:

ARTICULATA.

Crustacea.

Hippolyte aculeata.	Diastylis quadrispinosa.	Balanus porcatus.
Ptilocheirus pinguis.		

Annelida.

Nephthys ingens.	Trophonia aspera.	Terebellides Stroemi.
Rhynchobolus albus.	Ammochares, sp.	Myxicola Steenstrupii.

MOLLUSCA.

Bela decussata.	Margarita obscura.	Eugyra pilularis.
Natica clausa.	Cylichna alba.	Amarœcium pallidum.
Scalaria Grœnlandica.	Yoldia thraciformis.	

RADIATA.

Cerianthus borealis V.	Eudendrium ramosum.

Farther to the west, off the mouth of Casco Bay, and about two to three miles south of Half-way Rock, in 27 fathoms, we made another haul, very similar to the one in 33 fathoms, described above. The bottom was here composed of coarse sand and gravel, pebbles, small stones, and broken shells, with some mud. A large proportion of the species given in the list for the 33-fathom locality also occurred at this place, with many additional ones, among which were the following:

Crustacea.

Eupagurus Bernhardus.	Cumacea, two sp.	Ampelisca, sp. with red dorsal spots.
Crangon vulgaris.	Œdiceros lynceus.	Ampelisca, small sp.
Hippolyte Fabricii.	Ptilocheirus pinguis.	Anthura brachiata.

Annelida.

Nephthys ingens.	Praxilla zonata V.	Pista cristata.
Ammochares, sp.		Terebellides Stroemi.

Gastropoda.

Bela decussata.	Lunatia immaculata.	Cylichna alba.
Scalaria Grœnlandica.	Margarita obscura.	Philine angulata.
Natica clausa.		

Lamellibranchiata.

Cryptodon Gouldii.	Astarte quadrans.	Modiolaria nigra.
Cyclocardia Novangliæ.	Yoldia sapotilla.	

Echinodermata.

Hippasteria phrygiana, one large specimen.

A number of dredgings were made on and near East and West Cod Ledges, several miles off Cape Elizabeth. The shallower parts of these, in 10 to 15 fathoms, are very rough and rocky, so

that in some places the dredge could not be used, and even the tangles suffered seriously by the iron frame becoming caught and jammed among the rocks so firmly that it could not be extricated without using force sufficient to bend and twist the stout iron crossbar. At somewhat greater depths, in 20 to 30 fathoms, farther away from the crests of these ledges, the bottom was generally stony and gravelly, though often rough, and the dredges were used with good success. Most of the species from these localities have been enumerated in the two preceding lists, and need not be repeated here, but a considerable number of additional ones occurred. The roughest parts of the ledges, in 10 to 15 fathoms, are overgrown with red algæ, and among these the reddish variety of cod, known as "rock-cod," abounds. Here also a large number of interesting crustacea were obtained, most of them having red colors, evidently adapting them for concealment among the algæ.

Several of these occurred also in the previous lists, but are repeated here to show more fully the peculiar character of the fauna of these rough ledges. We ascertained that the cod-fish caught here feed chiefly on these crustacea, their stomachs often being filled with crabs, shrimps, and smaller species named below, together with more or less numerous Mollusca, Holothurians, Ophiurans, etc. The *Ophiopholis aculeata* was a common and important part of their diet, and several specimens of a large *Thyonidium* were taken from the stomach of a cod, at this place, though we did not dredge it at all, either here or elsewhere.

Among the species that occurred on the Cod Ledges, are the following:

Pycnogonida.

Phoxichilidium femoratum.	Nymphon, sp.

Crustacea.

Hyas coarctatus.	H. spina.	Amphithoë, sp.
Cancer irroratus.	H. Phippsii.	Cerapus rubricornis.
Eupagurus Kroyeri.	H. pusiola.	Unciola irrorata.
E. pubescens.	Crangon boreas.	Caprella, sp.
E. Bernhardus.	Pandalus annulicornis.	Praniza cerina.
Hippolyte Fabricii.	Paramphithoë pulchella.	Balanus porcatus, etc.
H. aculeata.		

Annelida.

Eunoa Œrstedii.	Euphrosyne borealis.	Potamilla oculifera.
Lepidonotus squamatus.	Amphitrite cirrata.	Spirorbis lucidus.
Harmothoë imbricata.	Scione lobata.	S. quadrangularis.
Phyllodoce catenula.	Thelepus cincinnatus.	Vermilia serrula.

Gastropoda.

Trophon scalariformis.	Menestho albula.	Trachydermon ruber Carp.
Buccinum undatum.	Margarita obscura.	T. albus Carp.
Neptunea curta.	M. cinerea.	Tonicella marmorea Carp.
Trichotropis borealis.	Lepeta cæca.	
	Doris planulata.	

Lamellibranchiata.

Saxicava arctica.	Cyclocardia borealis.	Modiolaria discors.
Cardium pinnulatum.	C. Novangliæ.	Anomia aculeata.
Astarte undata.	Modiola modiolus.	

Tunicata.

Ascidiopsis complanatus.	Cynthia pyriformis.	Leptoclinum albidum.
	Amarœcium glabrum.	L. luteolum.

Brachiopoda.

Terebratulina septentrionalis.

Polyzoa.

Alcyonidium, red sp.	Tubulipora patina.	Lepralia, several sp.
Crisia eburnea.	Caberea Ellisii.	

Echinodermata.

Lophothuria Fabricii.	Asterias vulgaris.	Cribrella sanguinolenta.
Thyonidium, sp.	Leptasterias, sp.	Ophiopholis aculeata.
Strongylocentrotus Dröbachiensis.	Stephanasterias albula Verrill.	Ophioglypha robusta.

Acalephæ.

Lucernaria quadricornis	Calycella syringa.	Sertularella polyzonias.
Obelia geniculata.	Lafoëa dumosa.	S. tricuspidata.
Campanularia volubilis.	Sertularia pumila?	Halecium muricatum.
C. integra.	S. argentea.	Tubularia indivisa.

Also species of *Grantia*, *Polymastia*, *Halichondria*, *Trichostemma* and numerous other sponges, not determined.

ALGÆ.

The following occurred in 12½ fathoms:

Agarum Turneri.	Euthora cristata.	Corallina officinalis.
Delesseria sinuosa.	Ptilota serrata.	Lithothamnion polymorphum.
D. alata.	Callithamnion Pylaisæi, with tetraspores.	
Calliblepharis ciliata.		

FAUNA OF CASCO BAY, IN SHALLOW WATER.

In Casco Bay, among the islands, in moderately shallow water, there is great diversity in the character of the bottom, and here a large amount of profitable dredging has been done.* Most of the species are decidedly boreal and arctic forms, which we had previously dredged in the Bay of Fundy, and farther north. The depth varied from 3 or 4 to about 30 fathoms. Some of the best localities on hard bottoms were found to be in Hussey Sound; off Cow Island; off the northern end of Peak's Island; off Witch Rock; off the Green Islands; off Whaleboat Island, in Broad Sound; and in the main ship-channel, off Fort Preble, etc. In these localities the bottom was composed of gravel and small stones, and occasionally of rough rocks with broken shells, gravel, etc., overgrown by an abundance of coarse massive sponges, among which were several species of *Reniera*, *Halichondria*, *Suberites*, *Polymastia*, *Tethya hispida* Bowerbank, etc., together with more delicate species belonging to *Chalina*, *Isodictya*, etc.

Several species of calcareous sponges also occurred, among which there were two or three species of *Grantia* (*Sycandra* Hæckel), a small species of *Leucandra*, on algæ; and a species, apparently undescribed (*Leucosolenia cancellata* Ver.), which forms small rounded or irregular cerebriform masses, usually less than an inch in diameter, consisting of an intricate net-work of slender anastomosing tubes, which give the surface a cancellated or pitted character. This is not uncommon on rocks and shells. Another peculiar and elegant species occurred once off Witch Rock, attached to *Terebratulina;* this forms deep goblet-shaped or campanulate cups, with a wide opening and smooth acute rim at the

*Numerous dredgings had also been made previous to our visit in the shallower waters of Casco Bay, by Mr. C. B. Fuller and others, during several years. A large and valuable collection of the shells and other marine invertebrates, mainly collected by Mr. Fuller, contained in the Museum of the Portland Society of Natural History, was burned in the great fire of 1866. Since that time he has accumulated for the Society another valuable collection, in which there are some species not obtained by our party. Dr. J. W. Mighels many years ago made a large collection of the shells of Casco Bay, chiefly from the shores and from fish-stomachs. This collection became the property of the same Society, and was destroyed by the previous fire, in which all its collections were lost. He published a catalogue of the shells of Casco Bay, etc., in the "Boston Journal of Natural History," vol. iv, p. 108, 1843. Professor E. S. Morse also made a choice collection of the shells of Casco Bay, mostly from the shores and shallow waters, previous to 1860. His collection is now in the Museum of Comparative Zoology. In this paper no attempt has been made to compile from these and other sources such species as we did not obtain. All the results given, unless otherwise stated, are based on our own observations, made for the most part this season.

top. In our specimen there are two cups, partially united at the base, nearly an inch high and about a third of an inch in diameter. The surface is even, minutely porous, and but slightly hispid externally. This appears to be a new species of *Leucandra* Hæckel, which I propose to call *L. cyathus*.

Among the more interesting crustacea dredged on such bottoms were numerous beautifully colored shrimp, belonging to six species of *Hippolyte* and the common *Pandalus annulicornis;* also several peculiar Amphipods, among which the *Acanthozone cuspidata* is conspicuous, on account of its numerous spines. An undetermined species of *Mysis* is not uncommon. Of Annelides several new and many rare forms occurred. Among the new species are *Enipo gracilis* (Plate 5, fig. 3), remarkable among the scaly worms for its slenderness and the small size of the scales, which only imperfectly clothe the anterior part of the back; the *Stephanosyllis picta* (Plate 4, fig. 1), a small but handsomely colored worm, belonging to a genus hitherto known only from the Mediterranean; *Procerea gracilis* (Plate 3, fig. 2), another allied species of small size but very active in its movements; *Praxilla zonata* (Plate 5, fig. 4), conspicuous on account of the bright red bands which surround the anterior part of its body. Other interesting species are *Eulalia pistacia* V. (Plate 4, fig. 2), which is usually of a bright epidote-green color and very lively and graceful in its movements; *Phyllodoce catenula*, quite as lively as the last, and more slender, with three rows of brown spots along its back; *Cirratulus cirratus* and *Scione lobata* M., which have not been recorded previously from our coast; *Vermilia serrula* Stimpson (Plate 4, fig. 3), remarkable for the two lateral chambers added to its tube when mature. Numerous interesting Ascidians also occurred, among them the rare *Chelyosoma geometricum* Stimpson (Plate 1, fig. 6), hitherto found only in the Bay of Fundy. This was dredged off Witch Rock, in 18 fathoms. Echinoderms are abundant and are represented by several interesting species, among which are two species of *Thyonidium*, and *Pentacta calcarea*, which were rather rare; *Pentacta frondosa* was only occasionally met with, of large size; good sized specimens of *Lophothuria Fabricii* were occasionally dredged, and the young were not uncommon; *Ophiopholis aculeata*, *Asterias vulgaris*, *Cribrella sanguinolenta* and *Strongylocentrotus Dröbachiensis* were abundant, but *Solaster endeca* and *Pteraster militaris* were comparatively rare and of small size.

The *Astrophyton Agassizii*, so abundant in the Bay of Fundy, and also in some parts of Massachusetts Bay, was not met with.

Hydroids of many kinds were abundant, and among them there are quite a number of species new to our coast. The beautiful *Campanularia integra* occurred in profusion on the fronds of *Agarum Turneri*, with *Obelia geniculata*. *Campanularia angulata* and *C. fragilis*, *Calycella pygmœa*, and *Halecium tenellum* are other interesting additions to our fauna.

LIST OF SPECIES INHABITING HARD BOTTOMS OF CASCO BAY, IN SHALLOW WATER.

The following are some of the more characteristic species dredged on the hard bottoms, in 8 to 30 fathoms:

ARTICULATA.

Crustacea.

Cancer irroratus.	Hippolyte gibba.	Podocerus fucicola.
C. borealis.	H. Phippsii.	Cerapus rubricornis.
Hyas coarctatus.	Pandalus annulicornis.	Ptilocheirus pinguis.
H. araneus.	Mysis, sp.	Unciola irrorata.
Eupagurus Bernhardus.	Diastylis, sp.	Caprella, sp.
E. Kroyeri.	Mœra Danæ.	Praniza cerina.
E. pubescens.	Melita dentata.	Idotea Tuftsii.
Crangon vulgaris.	Vertumnus serratus.	I. phosophorea.
Hippolyte spina.	Acanthozone cuspidata.	Balanus porcatus.
H. Fabricii.	Paramphithoë cataphracta.	B. crenatus.
H. aculeata.		
H. pusiola.		

Annelida.

Lepidonotus squamatus.	Cirratulus cirratus.	Polycirrus, phosphorescent sp.
Eunoa Œrstedii.	Dodecacerea concharum.	Myxicola Steenstrupii.
Harmothoë imbricata.	Praxilla zonata V.	Potamilla oculifera (Leidy).
Enipo gracilis V.	Nicomache lumbricalis.	Sabella zonalis Stimp.
Cryptonota citrina.	Trophonia aspera.	Chone, sp.
Phyllodoce catenula V.	Tecturella flaccida.	Euchone elegans V.
Eulalia pistacia V.	Brada granosa.	Spirorbis lucidus.
Nereis pelagica.	Sternaspis fossor.	S. nautiloides?
Stephanosyllis picta V.	Cistenides granulatus.	S. quadrangularis St.
Procerea gracilis V.	Thelepus cincinnatus.	Vermilia serrula.
Autolytus cornutus.	Scione lobata.	Filigrana implexa.
Autolytus, sp.	Amphitrite cirrata.	
Nothria conchylega.	A. intermedia.	
Polydora, sp. (in shells).		

Gephyrea.

Phascolosoma cæmentarium.	Phascolosoma, sp. nov.

Turbellaria.

Cosmocephala Stimpsoni V.
Nemertes affinis.
Leptoplana ellipsoides.

MOLLUSCA.

Gastropoda.

Bela harpularia.
B. decussata.
B. turricula.
B. pleurotomaria.
Admete viridula.
Trophon clathratus.
Buccinum undatum.
Neptunea decemcostata.
N. curta (Jeffreys' sp.).
Neptunella pygmæa V.
Tritia trivittata.
Astyris zonalis V. (dissimilis St.).
A. rosacea.
Trichotropis borealis.
Lacuna vineta.
L. neritoidea.
Natica clausa.
Lunatia heros.
S. Grœnlandica.
L. immaculata.
Crucibulum striatum.
Velutina zonata.
V. lævigata.
Lamellaria perspicua.
Menestho albula.
Scalaria Grœnlandica.
Margarita obscura.
M. Grœnlandica.
M. cinerea.
M. helicina.
Calliostoma occidentale
Diadora noachina.
Lepeta cæca.
Acmæa testudinalis, var.
Cylichna alba.
Tergipes despectus.
Æolis Mananensis.
Dendronotus arborescens.
Doris planulata.
Onchidoris pallida.
Polycera Lessonii.
Doto coronata.
Tonicella marmorea Carp.
Trachydermon albus Carp.
Trachydermon ruber Carp.
Hanleia mendicaria Carp.
Stimpsoniella Emersonii.

Lamellibranchiata.

Saxicava arctica.
Thracia truncata.
Mya arenaria (young).
Cyprina Islandica.
Cardium pinnulatum.
C. Islandicum.
Cyclocardia borealis.
C. Novangliæ.
Astarte undata.
A. quadrans.
Crenella glandula.
Mytilus edulis.
Modiola modiolus.
Modiolaria nigra.
M. discors (lævigata).
M. corrugata.
Pecten Islandicus.
P. tenuicostatus.
Anomia aculeata.

Tunicata.

Boltenia Bolteni.
Cynthia pyriformis.
C. echinata.
C. carnea.
Ascidiopsis complanatus.
Ciona tenella.
Chelyosoma geometricum St.
Molgula pannosa.
M. retortiformis.
M. papillosa.
Amarœcium glabrum.
A. pallidum.
Lissoclinum, sp.
Leptoclinum albidum.
L. luteolum.

Brachiopoda.

Terebratulina septentrionalis.

Polyzoa.

Idmonea pruinosa.
Crisia eburnea.
Tubulipora crates.
T. flabellaris.
Discoporella verrucosa.
Alcyonidium (red sp., on shells).
Caberea Ellisii.
Bugula Murrayana.
B. fastigiata.
B. avicularia.
Cellularia ternata.
Gemellaria loricata.
Flustra papyracea (?)
Membranipora pilosa.
M. lineata.
Lepralia Pallasiana.
Lepralia, several sp.
Discopora coccinea.
Cellepora scabra.
C. ramulosa.

RADIATA.

Echinodermata.

Pentacta frondosa.	T. hyalinum.	Cribrella sanguinolenta.
P. calcarea.	Strongylocentrotus Dröbachiensis.	Solaster endeca (small).
P. minuta.	Asterias vulgaris.	Pteraster militaris (small).
Lophothuria Fabricii.	A. littoralis (St.).	Ophiopholis aculeata.
Psolus plantapus, young.	Leptasterias, sp.	Ophioglypha robusta.
Thyonidium productum.	Stephanasterias albula.	Amphipholis elegans.

Acalephæ.

Lucernaria quadricornis	C. fragilis.	Sertularia argentea.
Obelia geniculata.	Clytia Johnstoni.	S. cupressina.
O. longissima.	Calycella syringa.	S. latiuscula.
O dichotoma.	C. pygmæa.	Diphasia fallax.
Gonothyrea hyalina.	Halecium muricatum.	D. rosacea.
G. gracilis.	H. tenellum.	Sertularella polyzonias.
G. Loveni.	H. Beanii.	S. tricuspidata.
Campanularia flexuosa.	H. halecinum.	Hydrallmania falcata.
C. volubilis.	Lafoëa fruticosa.	Coppinia arcta.
C. neglecta.	L. dumosa.	Thamnocnida tenella.
C. integra.	L. gracillima.	Tubularia indivisa.
C. caliculata.	Filellum serpens.	Acaulis primarius.
C. Hincksii.	Grammaria abietina.	Eudendrium capillare.
C. verticillata.	Opercularella lacerata.	E. ramosum.
C. angulata.	Antennularia antennina.	Hydractinia polyclina.

Anthozoa.

Metridium marginatum.	Alcyonium rubiforme.	Alcyonium carneum.
Urticina crassicornis.		

PROTOZOA.

Spongiæ.

Grantia ciliata.	Polymastia, new sp.	Cliona, sp.
Grantia coronata. [V.	Tethya hispida (Bowerbank).	Isodictya, sp.
Leucosolenia cancellata	Halichondria, sp.	I. lobata (Esper sp.).
Leucandra, sp.	H. pannosa.	I. infundibuliformis.
L. cyathus V.	Reniera, several sp.	Chalina oculata.
Polymastia robusta? Bowerbank.	Suberites, sp.	

Besides the species enumerated above, there were many others that have not yet been identified. Many that occurred less frequently on the hard bottoms than on sandy or muddy ones have also been omitted from the list.

Very few genuine sandy bottoms were met with, and these were generally of small extent, so that the sand was nearly always mixed with gravel, pebbles, or mud, when brought up in the dredge,

and there was, necessarily, a corresponding mixture of the animals inhabiting these different kinds of bottoms. Most of the species found on such bottoms are included in the preceding list. A number of species occurred, however, on sandy bottoms more frequently or in greater abundance than elsewhere. Among these were the following:

Crangon vulgaris, *Unciola irrorata*, *Idotea Tuftsii*, *Epelys montosus* Harger, *Praxilla zonata* V. (Plate 5, fig. 4), *Clymenella torquata* V., *Cistenides granulatus*, *Tetrastemma*, sp., *Ophionemertes agilis* V. (Plate 2, fig. 4), *Lunatia heros*, *Menestho albula*, *Utriculus pertenuis*, *Cochlodesma Leanum*, *Clidiophora trilineata*, *Lyonsia hyalina*, *L. arenata*, *Mactra polynyma* (*ovalis* Gould), *Astarte castanea*, *A. quadrans*, *Cyprina Islandica*, *Echinarachnius parma*.

FAUNA OF THE MUDDY BOTTOMS IN SHALLOW WATER.

Muddy bottoms of various grades, and at all depths to 40 fathoms, were frequent in Casco Bay, especially in the sheltered coves and channels among the islands, and in the several branches or fiords into which the northeastern portion of the bay is divided. There is considerable diversity in the character of the fauna in the different parts. The deeper localities have a very northern fauna, similar in many respects to that of the muddy bottoms of the deep outer water; while the shallow localities, especially in the inner harbor of Portland and in Back Cove, have a less northern fauna, and even yield a few decidedly southern forms, such as *Libinia canaliculata*, *Limulus Polyphemus*, etc.

In the table on page 344 the temperatures of the water in many of these localities are given.

The following table contains a series of temperatures taken by Commander Beardsley, at the anchorage of the steamer, in "Blue Light Cove," between Peak's Island and Hog Island, which will serve to give a good idea of the average temperature of the shallow waters among the islands in Casco Bay.

TEMPERATURES TAKEN IN SHALLOW WATER IN "BLUE LIGHT COVE."

Date	Locality.	Weather.	Hour.	Tide.	Temperature.			Depth in fathoms.	Nature of bottom.
					Air.	Surface.	Bottom.		
July									
27	Blue Light Cove.	Rainy	8 A.M.	1 h. flood	61°	59°	56°	3	Muddy.
"	" "	"	8 P.M.	½ "	60	59	56	3	"
28	Off Evergreen Landing.	Clear	12 M.	4 "	65	60	56	3	"
"	Blue Light Cove.	"	8 A.M.	l. w. slack	65	60	56	3	"
"	" "	"	8 P.M.	l. w. slack	66	62	58	3	"
29	" "	Rainy	8 A.M.	5 h. ebb	60	58	56	1½	"
"	" "	"	8 P.M.	5½ "	66	60	57	2	"
30	" "		8 A.M.	4 "	68	64	60	1½	"
"	" "		8 P.M.	4½ "	70	66	61	2	"
31	" "	Clear	8 A.M.	3½ "	71	62	58	2	"
"	" "	"	8 P.M.	3 "	66	62	59	2	"
Aug.									
1	" "	Cloudy	8 A.M.	2½ "	62	60	56	2	"
2	" "	"	8 P.M.	2 "	68	63	57	2	"
3	" "	"	8 A.M.	1½ "	66	61	57	2	"
4	" "	Clear	8 A.M.	1 "	71	68	56	3½	"
"	" "	"	8 P.M.	1½ "	70	62	58	3	"
6	" "	"	8 A.M.		68	63	57	3	"
"	" "	"	8 A.M.		68	62	59	2½	"
"	" "	"	8 P.M.		64	61	57	2	"
7	" "	Cloudy	8 A.M.		65	61	58	2	"
14	" "	"	8 A.M.		60	58	56	3	"
19	" "	Rainy	8 A.M.		61	58	57	2	"
24	" "	"	8 A.M.		63	61	60	2	"
"	" "	Clear	8 P.M.		62	58	57	2	"
25	" "	"	8 A.M.		61	58	56	2	"
27	" "	"	8 A.M.		60	58	57	2	"
29	" "	"	8 A.M.		66½	61	57	2	"

LIST OF SPECIES INHABITING THE MUDDY BOTTOMS OF CASCO BAY, IN 2 TO 40 FATHOMS.

Pycnogonida.

Nymphon, sp.
Pallene, sp.
Phoxichilidium femoratum.

Crustacea.

Libinia canaliculata.
Hyas coarctatus.
Eupagurus Kroyeri.
E. pubescens.
E. Bernhardus.
Crangon vulgaris.
Pandalus annulicornis.
Hippolyte Gaimardii.
H. pusiola.
H. Fabricii.
Mysis Americana.
M. stenolepis Smith.
Diastylis sculpta.
D. quadrispinosa.
Eudorella hispida.
Œdiceros lynceus.
Unciola irrorata.
Cerapus rubricornis.
Ptilocheirus pinguis.
Byblis Gaimardii.
B. serrata.
Phoxus Kroyeri.
Corophium cylindricum.
Pontoporeia, sp.
Haploops, sp.
Ampelisca, with red spots.
Orchomene, sp.
Limnoria terebrans, in wood, 10 fathoms.
Idotea phosphorea Harg.
Epelys montosus Harg.
Limulus Polyphemus.

Annelida and Gephyrea.

Aphrodite aculeata.
Harmothoë imbricata.
Pholoë minuta.
Nepthys ciliata.
N. ingens St.
Phyllodoce catenula V.
Phyllodoce, sp.
Eulalia pistacia V.
Eteone pusilla.
Nereis pelagica.
Ninoë nigripes V.
Lumbriconereis obtusa V.
L. fragilis.
Goniada maculata.
Rhynchobolus albus.
Polydora, sp., in shells.
Scolecolepis cirrata.
Spio, sp.
Anthostoma acutum V.
Trophonia aspera V.
Ammotrypane fimbriata V.
Oterlia, sp.
Sphenaspis fossor.
Chætozone setosa.
Cirratulus cirratus.
Clymenella torquata.
Rhodine Loveni.
Nicomache lumbricalis.
Maldane Sarsii.
Praxilla, sp.
P. zonata V.
P. gracilis.
Ammochares, sp.
Ancistria capillaris V.
A. acuta V.
Areniella filiformis V.
Cistenides granulatus.
C. Gouldii V.
Ampharete gracilis.
A. Finmarchica?
Amphicteis Gunneri.
Melinna cristata.
Amphitrite brunnea V.
A. intermedia.
A. cirrata.
Scione lobata.
Polycirrus, sp.
Chone, sp.
Euchone elegans V.
Ichthyobdella versipellis Dies (on Cottus).
Chætoderma nitidulum.
Phascolosoma cæmentarium.

Turbellaria.

Cosmocephala, orange sp.
C. Stimpsonii V.
Ophionemertes agilis V.
Tetrastemma, sp.
T. vittata V.
Meckelia lurida V.
Leptoplana ellipsoides.

Gastropoda.

Bela harpularia.	L. Grœnlandica.	T. acicula.
B. turricula.	Aporrhais occidentalis.	Margarita obscura.
B. pleurotomaria.	Velutina lævigata.	M. cinerea.
Buccinum undatum (young).	Trichotropis borealis.	Utriculus pertenuis.
Neptunella pygmæa.	Rissoa carinata.	Cylichna alba.
Tritia trivittata.	R. exarata.	Philine quadrata.
Lunatia heros, var.	R. (?) eburnea.	P. lineolata.
L. immaculata.	Scalaria Grœnlandica.	Entalis striolata.
	Turritella erosa.	

Lamellibranchiata.

Zirphæa crispata (in wood).	Callista convexa.	Y. myalis.
Cyrtodaria siliqua, young.	Cyprina Islandica.	Y. limatula.
Neæra pellucida.	Cardium pinnulatum.	Y. thraciformis.
Mya arenaria (young).	C. Islandicum.	Y. obesa.
Saxicava arctica.	Serripes Grœnlandicus.	Nucula tenuis.
Lyonsia hyalina.	Lucina filosa.	N. delphinodonta.
Thracia Conradi.	Cryptodon Gouldii.	N. proxima.
T. myopsis.	Solenomya velum.	Crenella glandula.
T. truncata.	Cyclocardia borealis.	C. decussata.
Periploma papyracea.	C. Novangliæ.	Modiolaria nigra.
Ensatella Americana.	Astarte lens.	M. discors (lævigata).
Macoma sabulosa.	A. undata.	M. corrugata.
M. fragilis (fusca).	Leda tenuisulcata.	Mytilus edulis.
	Yoldia sapotilla.	Pecten tenuicostatus.

Tunicata.

Molgula pannosa.	Eugyra pilularis.

Echinodermata.

Asterias vulgaris.	Ophioglypha Sarsii.	Ophiopholis aculeata.
Ctenodiscus crispatus.	O. robusta.	

Hydroidea.

Corymorpha pendula.	Sertularia argentea (on shells).	Sertularella tricuspidata (on shells).
Hydractinia polyclina.		

Anthozoa.

Metridium marginatum (on shells).	Edwardsia farinacea V.	Cerianthus borealis V.
	E. sipunculoides.	

FAUNA OF THE SHORES.

The shores of the islands and of Cape Elizabeth afford excellent collecting grounds at low-water, owing to their diversified character. Many parts of these shores are abrupt and rocky,

Plate 3.

Fig. 1.

Fig. 2.

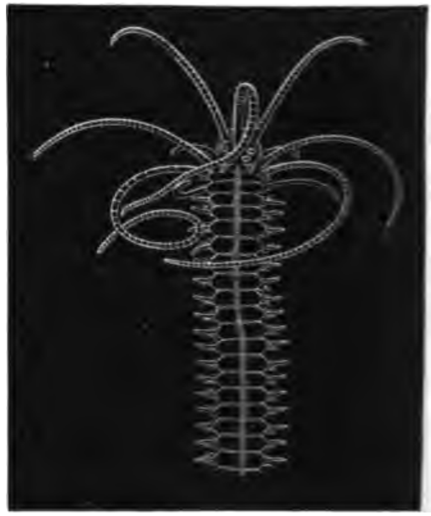


Fig. 3.

Fig. 4.

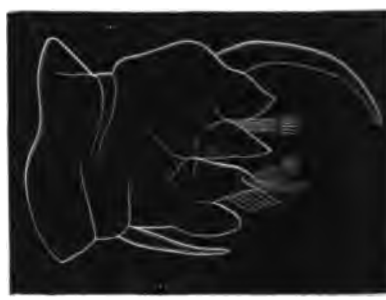


Fig. 5.

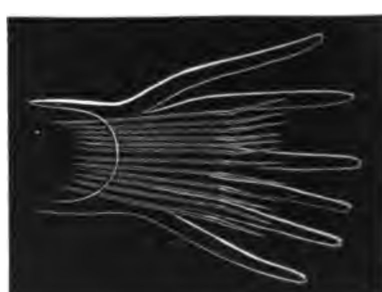


Fig. 1.

Fig. 3.

Fig. 4.

Fig. 1.

Fig. 2.

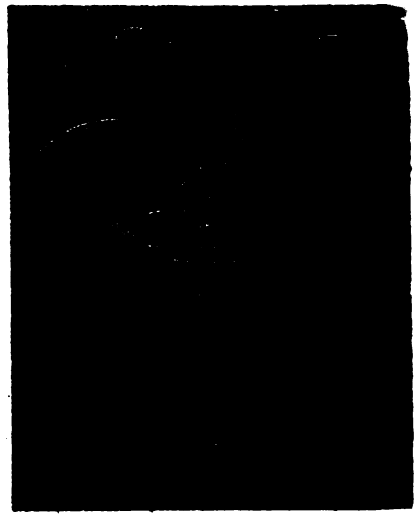


Fig. 3.

Fig. 4.

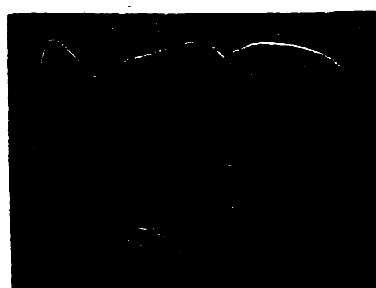


Fig. 5.

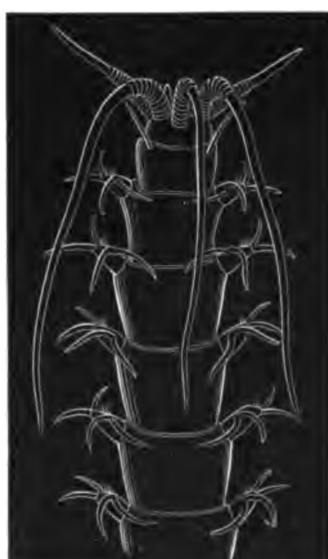
Plate 4.

Fig. 1.

Fig. 2.

Fig. 3.

Fig. 4.



and often formed of broken and precipitous ledges of hard metamorphic slates and thin-bedded grits, or altered sandstones, in some places passing into gneissose rocks, and generally dipping at a high angle. Tide-pools are of frequent occurrence, and often of large size, and afford excellent opportunities for obtaining the shallow-water and littoral species of animals, and many beautiful algæ. One very large pool on Ram Island Ledges is especially rich, and was visited several times with profit. In this pool young lobsters of all sizes are very abundant beneath the stones. Two species of Chitonidæ also occurred here, together with many other species not usually to be found at low-water mark. Hydroids and Bryozoa, of many species, are abundant in this and other similar pools. The shore species obtained upon the islands and outer shores of the bay are nearly all boreal or arctic forms. In the harbor of Portland, on the piles of the wharves, etc., a few more southern species are met with, though the northern ones predominate even there.

Several insects are met with between tides. Among these are *Chironomus oceanicus*, and the larvæ, about two inches long, of a fly, probably an *Eristalis*, which live in small tide-pools, under stones, and extend their long tapering tails up to the surface; the pupæ of a fly allied to *Ephydra;* a species of *Bledius*, and several other beetles. A *Phoxichilidium* and two or three species of mites were also collected between tides. In a pool of brackish water, at high-water mark, among the ledges of Cape Elizabeth, several species of water beetles, the larvæ of a species of mosquito (*Culex*) and other dipterous larvæ were obtained. This pool was filled with green marine algæ (*Enteromorpha*).

LIST OF SPECIES INHABITING THE SHORES OF CASCO BAY, BETWEEN TIDES.

Crustacea.

Cancer borealis.
C. irroratus.
Hippolyte pusiola.
H. spina.
Crangon vulgaris.
Eupagurus Bernhardus.
E. Kroyeri.
Gammarus ornatus.
Gammarus marinus.
Hyale littoralis.
Talorchestia megalophthalma Smith.
Orchestia agilis Smith.
Calliopius læviusculus.
Amathella angulosa (?)
Pontogenia inermis.
Amphithoë maculata.
Cerapus rubricornis.
Corophium, sp.
Unciola irrorata.
Jæra copiosa.
Idotea irrorata.
I. phosphorea Harger.
Erichsonia filiformis Harger.
Balanus balanoides.

Annelida.

Lepidonotus squamatus
Harmothoë imbricata.
Eunoa Œrstedii.
Nephthys cæca.
Eulalia pistacia V.
Eteone, sp.
Phyllodoce catenula V.
Lumbriconereis fragilis
Stephanosyllis ornata Verrill.
Autolytus cornutus.
Proceræa gracilis V.
Nereis virens.
N. pelagica.
Polydora, sp.
Anthostoma fragile V.
Rhynchobolus dibranchiatus.
Cirratulus cirratus.
Nicomache, sp.
Clymenella torquata V.
Notomastus luridus V.
Cistenides granulatus.
Amphitrite brunnea V. (St. sp.).
Polycirrus, sp.
Myxicola Steenstrupii.
Fabricia Leidyi V.
Potamilla oculifera V.
Spirorbis borealis.
Clitellio irrorata V.
Halodrilus littoralis V.

Turbellaria.

Nemertes viridis.
N. socialis.
Borlasia, sp.
Tetrastemma, three sp.
Cosmocephala Stimpsonii V.
Monotus spatulicauda.
Monocelis agilis ?
Dinophilus borealis.
Fovia affinis.
Leptoplana ellipsoides.

MOLLUSCA.

The shore Mollusca are decidedly northern, and the species are not very numerous. Among the most characteristic are the following:

Purpura lapillus.
Buccinum undatum.
Ilyanassa obsoleta.
Tritia trivittata.
Lunatia heros.
Littorina littorea.
L. rudis.
L. palliata.
Lacuna vincta.
L. neritoidea.
Rissoa aculeus.
Littorinella minuta St.
Skenea planorbis.
Acmæa testudinalis.
Trachydermon ruber.
T. albus.
Æolis papillosa.
Tergipes despectus.
Dendronotus arborescens.
Doto coronata.
Polycera Lessonii.
Doris, sp.
Saxicava arctica.
Mya arenaria.
Teredo, sp.
Zirphæa crispata.
Macoma fragilis.
Turtonia minuta.
Mytilus edulis.
Modiola modiolus.
Ascidiopsis complanatus V.
Amarœcium glabrum.
Crisia eburnea.
Alcyonidium hispidum.
A. hirsutum.
Bugula turrita V.
Membranipora pilosa.
M. lineata.

RADIATA.

Strongylocentrotus Dröbachiensis.
Asterias vulgaris.
A. littoralis.
Aurelia flavidula (strobila).
Obelia geniculata.
O. dichotoma.
Campanularia flexuosa.
C. fragilis.
Opercularella lacerata.
Sertularia pumila.
Sertularia argentea.
Sertularella rugosa.
Clava leptostyla.
Metridium marginatum.
Bunodes stella.

Several species of sponges are also common between tides.

On the sheltered muddy bottoms, from just below low-water mark, to the depth of about two fathoms, the eel-grass, *Zostera*

marina, grows in abundance, and in many places it was thickly covered with delicate Hydroids, among which *Obelia dichotoma* was the most abundant. Among the eel-grass many species of crustacea, worms and mollusks find congenial abodes, and furnish abundant food for the fishes that frequent such localities. Some of these are somewhat southern in character.

Among the Crustacea from the eel-grass were:—*Hippolyte Gaimardi; Crangon vulgaris; Mysis stenolepis* Smith; *M. Americana* Smith; *Calliopius læviusculus;* a new genus with very large epimera, allied to *Metopa;* a new species of *Munna*, a genus of isopod crustacea, new to the American coast; *Idotea irrorata*, etc.

From the piles of the wharves at Portland we obtained a great variety of sponges, hydroids, bryozoa, etc. The slender branched sponge, *Chalina oculata*, is here particularly abundant and fine; also the common large sea-anemone, *Metridium marginatum;* a beautiful Tubularian, in large clusters; and the compound Ascidian, *Amarœcium glabrum* V., with many other northern forms. The *Limnoria lignorum* was found in abundance, destroying the piles and timbers.

Among the more interesting littoral species obtained on the shores of Casco Bay and vicinity are *Littorina littorea* and the *Cancer borealis*. The latter is a large crab which has hitherto been very rare in all collections, and but imperfectly known; this we found in large numbers on the ledges at the northern end of Peak's Island and Pumpkin Knob, in tide-pools, or clinging to the sea-weeds in more exposed situations, but never concealed beneath the rocks with the *Cancer irroratus*, which was there abundant. The carapaces and claws of the former were also found in abundance at considerable distances from the shores, whither they had been carried by the gulls and crows. Owing to the exposed situations in which they live, they must fall an easy prey to rapacious birds. We obtained eighty-five specimens in one morning. The *Littorina littorea* occurs sparingly at various localities on the islands, but was found in great abundance at Scarboro, on the piles of a bridge, by Dr. Edw. Palmer. It has been supposed by several writers that this shell has been recently and accidentally introduced from Europe; but Dr. Dawson informs me that he collected it more than thirty years ago in the Gulf of St. Lawrence. It is abundant at Halifax, and we have other specimens from Kennebunkport, Me., Hampton Beach, N. H., and Provincetown, Mass.

There is really no sufficient evidence that it was not an inhabitant of our shores before the advent of Europeans, but local in its habitats. It may have become more diffused in recent times, by commerce, or it may have been overlooked formerly by collectors.

EXISTENCE OF SOUTHERN COLONIES, AND OTHER EVIDENCES OF FORMER CHANGES OF CLIMATE.

One of the localities, most interesting zoologically, that we visited, is a small shallow and sheltered cove, at the upper end of Quahog Bay, about thirty miles northeast from Portland. This place is well known to be inhabited by the round-clam or "Quahog" (*Venus mercenaria*), which is not found living elsewhere on the coast of Maine, so far as known to me. Indeed, this southern species is rare everywhere north of Cape Cod, on the New England coast, and is probably not to be found living north of Massachusetts Bay, except in the coves connected with Quahog Bay. It is also absent from the Bay of Fundy, but reappears in the southern and shallow parts of the Gulf of St. Lawrence. This anomalous distribution would be curious, even if it happened only in the case of this one species; but our investigation of this locality shows that there is quite a number of other southern species associated with the quahog, which have the same remarkable distribution, being absent along the rest of the northern coast of New England, and reappearing in the Gulf of St. Lawrence. There is, in fact, at this place a genuine colony of southern species, completely isolated from their co-species of the southern coast of New England, and surrounded on both sides by more northern forms. Several of these southern species, like the *Venus mercenaria*, *Crepidula convexa*, *Urosalpinx cinerea*, *Eupagurus longicarpus*, *Gammarus mucronatus*, *Epelys trilobus* Smith, *Nereis limbata*, *Meckelia ingens* Leidy, *Asterias arenicola*, etc., were not even met with among the islands and coves of Casco Bay; while others, such as *Ilyanassa obsoleta*, *Crepidula fornicata*, *C. plana*, *Limulus Polyphemus*, etc., occurred more or less frequently in the most sheltered and shallow waters of Casco Bay, though they are not found on the more exposed shores of Maine and New Hampshire, farther to the south and west, but have their true homes south of Cape Cod. Native oysters also occur, in a similar way, farther eastward than Quahog Bay, near Damariscotta, though it is not probable that they are indigenous elsewhere on the New England coast, north of Cape

Cod,—as they certainly are not north of Massachusetts Bay,—yet they reappear in the Gulf of St. Lawrence, with the other southern forms.

In fact, the southern part of the Gulf of St. Lawrence, from the Bay of Chaleur to Prince Edward Island and Cape Breton Island, is a region of shallow water, occupied by another southern colony, but a much larger one than that of Quahog Bay, and containing, perhaps, a few southern species that do not occur in the latter locality; though owing to the fact that we could spend but a few hours at this place, our collection is doubtless quite incomplete. On the other hand, we have, with the exception of the shells, very imperfect lists of the southern species inhabiting the colony in the Gulf of St. Lawrence, so that a complete comparison cannot be made, at present, except with the shells; these agree very closely, according to the lists given by Dawson, Bell and Whiteaves.

As the existence of these isolated southern colonies has an important bearing upon the question of former changes of climate on our coast, and as other facts, to be mentioned farther on, are intimately connected with them, I give here a list of the species obtained by us, in the cove referred to, so far as they have been identified.

LIST OF SPECIES COLLECTED AT LOW-WATER IN A SMALL COVE, AT THE UPPER END OF QUAHOG BAY.

Those with an asterisk prefixed are decidedly southern species, belonging properly to the region south of Cape Cod.

ARTICULATA.

Crustacea.

Cancer irroratus.	*G. mucronatus.	*Argulus, sp., on Fundulus pisculentus.
*Eupagurus longicarpus	Amphithoë, sp.	*Limulus Polyphemus.
Crangon vulgaris.	*Epelys trilobus Smith.	Balanus balanoides.
*Mysis stenolepis Smith	Idotea irrorata.	
Gammarus ornatus.	Limnoria lignorum.	

Annelida.

Lepidonotus squamatus.	Nereis virens.	Spirorbis borealis.
Nephthys ingens.	*Nereis limbata.	*Rhynchobolus dibranchiatus.
Eulalia, sp.	Fabricia Leidyi.	
Autolytus cornutus.		

Turbellaria.

*Meckelia ingens.	Nemertes viridis.	Procerodes Wheatlandi
Tetrastemma (green sp.).	*Nemertes socialis.	*Bdeloura candida (on Limulus).
	*Planocera, sp.	

MOLLUSCA.

Gastropoda.

*Urosalpinx cinerea.	*Crepidula convexa.	Lacuna vincta.
Purpura lapillus.	*C. fornicata.	Rissoa aculeus.
*Ilyanassa obsoleta.	*C. plana (with ova).	Littorinella minuta St.
Tritia trivittata.	Littorina rudis.	Acmæa testudinalis.
Natica heros.	L. palliata.	

Lamellibranchiata.

Saxicava arctica.	Macoma fragilis.	Mytilus edulis.
Mya arenaria.	*Petricola pholadiformis.	*Modiola plicatula.
*Venus mercenaria.		Anomia aculeata.
Tottenia gemma.		

Bryozoa.

Alcyonidium hispidum.	Alcyonidium hirsutum.	Vesicularia, sp.

RADIATA.

Echinodermata.

*Asterias arenicola.

Hydroidea.

Sertularia pumila.	Obelia geniculata.	Hydractinia polyclina.
S. argentea.	Clava leptostyla.	

Anthozoa.

Metridium marginatum.

Although the species in this list, that are not marked as southern, have a continuous range northward to the Gulf of St. Lawrence, and many of them to the Arctic Ocean, North Pacific, and northern Europe, they all extend as far south as Long Island Sound, and several of them even to North Carolina. Most of them are, therefore, northern species having a wide distribution, and their presence in this particular locality has no special significance.

In Quahog Bay itself we found the bottom composed of soft sticky mud, and in this we dredged, in four to six fathoms, a great number of large and fine specimens of *Yoldia limatula*, *Macoma sabulosa*, *Nephthys ingens*, and a number of other common species.

EVIDENCES OF CLIMATIC CHANGES.

That the Quahog Bay colony has formerly, and within the human period, been more extensive than at present, is shown: 1. By the fact that the quahogs have evidently been, at one time, more numerous and more generally diffused than now, for their shells are abundant in the mud, in places where no living ones could be found; 2. By the occurrence of oysters, in great quantities and of large size, in the ancient Indian shell-heaps of this region, and also near Damariscotta, while at present the oysters are found only at the latter place, and are few and small; 3. By the occurrence of the shells of the quahog, of large size, in the Indian shell-heaps on many of the islands in Casco Bay (these heaps consisting mainly of the shells of the "long clam," *Mya arenaria*, with a few bones of fishes, birds and mammals).

That at a more remote period, the marine climate of this region was still warmer,* and the southern species were more abundant than during the period when the Indian shell-heaps were formed, is shown by the occurrence of great beds of oyster-shells a few feet beneath the mud in Portland Harbor, where they are associated with quahogs and several other southern species, among which are *Callista convexa*, *Turbonilla interrupta* and *Pecten irradians*. The latter is not known to live, at present, north of Cape Ann, on the New England coast. It is absent, apparently, from the colony in the Gulf of St. Lawrence, as well as from that of Quahog Bay. It is very rare north of Cape Cod.†

The *Callista convexa* is still found sparingly in shallow, sheltered localities in Casco Bay, and rarely at Eastport, Me., but it is more common in the colony of the Gulf of St. Lawrence, and very common south of Cape Cod. But the oysters (*Ostrea Virginiana*) and "scollops" (*Pecten irradians*) had apparently become extinct in the vicinity of Portland Harbor before the period of the Indian shell-heaps, for neither of these species occurs in the heaps on the adjacent islands, while the quahogs lingered on until that time, but have subsequently died out everywhere

*The evidence here given is probably applicable chiefly to the temperature of the warmer months, or more properly to the reproductive season of the mollusks referred to, for the climatic distribution of most marine animals seems to depend mainly on the temperature of the season at which reproduction takes place.

†Willis includes this species in his nominal list of Nova Scotia shells, but without mentioning the special locality. It may, perhaps, occur in some of the sheltered localities near Halifax, where another southern colony exists.

in this region, except at Quahog Bay. The oysters have survived only in the locality near Damariscotta, though far less abundant there than during the Indian period.

The beds of dead shells of oysters, *Pectens*, etc., were found in making excavations in the harbor with mud-digging machines. These beds extend up to or above low-water mark, and are of great extent. Mr. C. B. Fuller, who has made a good collection of these shells for the Portland Natural History Society, informs me that the farmers have, in some instances, found it profitable to cart away these ancient shells for fertilizing purposes. The position of these beds indicates that no important change in the relative level of the land and water can have occurred in that region since they were formed. These beds are, of course, easily distinguished from the much more ancient Quaternary deposits that occur abundantly in the same region, but extend back several miles from the coast, and occur at all levels, from low-water mark to about 200 feet above high-water mark. The latter are characterized, in that region, by a more arctic assemblage of shells than that now inhabiting the adjacent waters, though most of the species still survive, in deep water, off the coast of Maine.

The facts above presented indicate: 1. That in the Post-pliocene or Champlain period the coast was at a lower level, and the marine climate of Casco Bay was colder than at present, probably about like that of the present Newfoundland and Labrador coasts; 2. That at a subsequent period, when the coast had attained nearly or quite its present level, the marine temperature was considerably higher than at present; 3. That the temperature of these waters has gradually declined, but was still somewhat higher at the period when the Indian shell-heaps were formed than at present.

That the existence and character of the southern colony in the Gulf of Saint Lawrence point to the same conclusion is sufficiently obvious. The survival of the southern species in that region is undoubtedly due to the great expanse of shallow water in that part of the gulf, which becomes well warmed up by the heat of the sun, in summer; and to the absence of tides sufficiently powerful to mix up thoroughly the very cold waters of the northern and deeper portions of the gulf with the warm waters of the southern part. Tides like those of the Bay of Fundy and coast of Maine would undoubtedly diminish at once this contrast

in the temperature of the different parts of the gulf, and greatly lessen the temperature of the southern part, by reason of the far greater volume of the cold water.

The *origin* of the southern species in the gulf is a totally different matter. I can explain their presence there in no other way than to suppose that they are survivors from a time when the marine climate of the whole coast, from Cape Cod to Nova Scotia and the Bay of Fundy, was warmer than at present, and these species had a continuous range from southern New England to the Gulf of Saint Lawrence. At that time there may have been a direct shallow passage from the Bay of Fundy across to the Gulf of St. Lawrence, for the land is there narrow and low; but of this we have no direct evidence. A *deep* channel there would act like the Straits of Belle Isle, and admit the cold arctic current to the coast of Maine; this may have been the case in Quaternary times.

The causes of such changes in the temperature of the water may have been entirely local, and due to changes in the relative level of the land and water, in adjacent regions. Thus a rise of the land in the region of Saint George's Bank, to the extent of 250 feet, would produce an island quite as large as the State of Massachusetts, and would thus very materially alter the climatic conditions of the "Gulf of Maine," between it and the New England coast. And it would add a great body of land, now represented by Le Have Bank, etc., to the southern part of Nova Scotia, and thus greatly narrow the channel between those banks and St. George's, as well as make it more shallow; this would doubtless greatly modify the tides, and greatly diminish their force and height on the northern coasts of New England, and in the Bay of Fundy, for the "Gulf of Maine" would then have much resemblance to the Gulf of Saint Lawrence in form and in the character and position of its main channel, and, therefore, its tides would also be similar; the small tides would allow greater differences between the temperatures of the shallow waters and deep waters, and would thus favor the southern species inhabiting shallow water. A rise of the land, of about the same amount, in the region of Newfoundland, would lay bare a great part of the Grand Banks, close up the Straits of Belle Isle, and more than double the size of Newfoundland, which would doubtless produce great climatic changes on the New England coast, as Professor Dana has suggested.

FOOD OF FISHES.

The stomachs of a large number of fishes of various kinds, recently caught in many different localities, have been examined by us, during this and previous seasons, in order to ascertain the precise nature of their food.

In this way a great amount of valuable information has already been accumulated. This subject is not, however, by any means exhausted, for since fishes do not feed upon the same food, in different places and at all seasons, it will be necessary to greatly multiply these observations in many different localities, in order to understand properly the character of their food. The task of identifying the various soft-bodied creatures, taken from the stomachs in a more or less digested condition, is by no means an easy one. Such contents can be best preserved for final examination by placing them at once in strong alcohol. The stomach should be opened as soon as possible after the fish is caught, for digestion goes on very rapidly, even after the death of the fish. Special attention has been paid to the food of the cod, haddock and mackerel this season.

DESCRIPTIONS OF SOME OF THE NEW, OR RECENTLY DESCRIBED SPECIES, FOUND IN CASCO BAY.

ANNELIDA.

Enipo gracilis Verrill. (Plate 5, figure 3.)

American Journal of Science, vol. vii, p. 407, 1874.

Body long and slender, quite narrow, the anterior part of the back only partially covered by small oval, smooth, translucent scales. Head rather elongated, tapering; eyes four, conspicuous. Setæ of the lower rami stout, with the terminal portion broad, short cuspidate, and armed with oblique rows of strong, sharp, ascending, unequal spines; tips naked, acute, curved, the lower ones most so. Length 50^{mm} to 60^{mm}; breadth 3^{mm} to 4^{mm}.

Casco Bay, 15 to 20 fathoms; Jeffrey's Bank, 80 fathoms.

Stephanosyllis ornata V. (Plate 4, figure 1.)

American Journal of Science, vol. vii, p. 132, Feb., 1874.

Body moderately slender, thickest near the middle, tapering slightly anteriorly, and rapidly posteriorly, the caudal portion acuminate, with two slender caudal cirri. Antennæ and tentac-

ular-cirri long, slender, and tapering, slightly and irregularly annulated, or transversely wrinkled; median antenna longest, reaching back to about the tenth segment; lateral antennæ about equal to the upper tentacular cirrus, or reaching to about the sixth body-segment; lower cirrus about half as long; dorsal cirrus of the second segment very long and slender, equalling or exceeding the median antenna; dorsal cirri of the third segment as long as those of the first, or longer, more than twice the diameter of the body; those of the fourth segment less than half as long; those farther back unequal in length. Head rounded in front and behind, broad, the anterior pair of eyes larger and wider apart than the posterior ones; "epaulets" conspicuous, lanceolate, extending back to the fourth segment. Color, in life, pale green, especially beneath and on the sides above; back, bright orange-red, with transverse lines of green at the articulations; setigerous lobes whitish; lateral cirri pale greenish white; antennæ and tentacular-cirri pale salmon, often tipped with pink; epaulets orange, centred with green, and bordered by a line of white, and with a red line along the edge; head pale yellow; eyes black. Length, 12^{mm}; breadth, $0{\cdot}75^{mm}$.

Casco Bay, 6 to 20 fathoms, stony; and in tide-pools at low-water.

Procerœa gracilis V. (Plate 3, figure 2.)

American Journal of Science, vol. vii, p. 132, 1874.

Body very slender, elongated. Head subcordate, longer than broad, rounded in front, posteriorly extending back in two short rounded lobes, not reaching beyond the buccal segment; anterior eyes considerably farther apart than the posterior ones. Antennæ and upper cirri of the first two segments very long and slender, faintly annulated; the median antenna is very much elongated, considerably longer than the lateral ones, and about equal to the dorsal cirri of the second segment; the lateral antennæ are about as long as the upper tentacular-cirri, or about five times the diameter of the body; the dorsal cirri of the third segment are about twice as long as the diameter of the body; the cirri on the succeeding segments are about half as long as the breadth of the body. Color, in life, pale greenish, with a narrow median dorsal line of dark brown, and a less distinct one on each

side, at the base of the lateral appendages; eyes black. Length, about 25^{mm}; breadth, 1^{mm}, or less.

Casco Bay, 10 to 20 fathoms; and in tide-pools.

Eulalia pistacia Verrill. (Plate 4, figure 2.)

First Report of the Commissioner of Fish and Fisheries, p. 584.

Body moderately slender, depressed. Head convex, shorter than broad; in preserved specimens, sides well rounded, posterior margin slightly emarginate; median odd antenna small, slender, considerably shorter than the head. Eyes large, brown. Tentacular cirri moderately long; the four posterior ones considerably longer than the others. Branchiæ narrow lanceolate anteriorly; ovate and leaf-like on the middle segments; longer and lanceolate posteriorly. Proboscis long, more or less clavate, smooth, but often showing longitudinal striations, and sometimes with a few very minute scattered papillæ toward the end; the orifice surrounded by a circle of numerous minute papillæ. Color bright yellowish green (epidote-green or pistachio-green), often with obscure darker markings posteriorly, and at the base of the appendages. Length up to 40^{mm}; breadth, $1{\cdot}5^{mm}$.

Vineyard Sound, 6 to 12 fathoms, among compound ascidians; off New Haven, 4 to 5 fathoms, among hydroids; Casco Bay, 8 to 20 fathoms.

Phyllodoce catenula Verrill. (Plate 3, figure 1.)

Op. cit., p. 587.

Head somewhat longer than broad, slightly cordate posteriorly, with the posterior angles well rounded, and the sides full and convex; front broadly rounded, and with a slight emargination in the middle. Eyes large, dark brown, placed on the dorsal surface of the head; antennæ rather long, slender. Tentacular cirri long and slender, the two posterior much longer than the others. Branchiæ of anterior segments broad ovate, with rounded tips; farther back larger and longer, ovate, leaf-like, with acuminate tips. Proboscis with twelve rows of papillæ on the basal portion, which are prominent, somewhat elongated, obtuse, seven or eight in the lateral rows, those in each row close together. Color of body and branchiæ pale green, with a median dorsal row of dark brown spots, one to each segment; and two lateral rows, in which

there is a spot at the base of each "foot;" head pale, or greenish white. Length up to 75^{mm}; breadth about $1 \cdot 5^{mm}$.

Watch Hill, Rhode Island, in 4 to 6 fathoms, among rocks and algæ, and in tide-pools; Wood's Hole, at surface, evening, July 3. Casco Bay, 8 to 30 fathoms; very common in the Bay of Fundy, from low-water to 50 fathoms.

This species is closely allied to *P. pulchella* Malmgren, from northern Europe, but differs somewhat in the form of the head, which is shorter and rounder in the latter; the branchiæ also differ in form. It is a very active species, and secretes a large quantity of mucus.

Nothria opalina Verrill. (Plate 4, figure 4.)

American Journal of Science, vol. v, p. 102, 1873.

Body long and slender, narrowed anteriorly, much depressed and of nearly uniform width throughout most of its length; the five anterior segments much longer than the others. Palpi inferior, rather large, hemispherical; antennæ small, ovate, close together, on the front of head. Three central tentacles very long and slender, tapering, acute, the basal portion regularly annulated and thickened for a considerable distance, beyond which the surface is smooth, with an occasional distant annulation; the central odd one is somewhat shorter and more slender than the two adjacent ones, which reach to or beyond the 10th segment; outer pair much shorter, being less than half the length of the central ones. Tentacular cirri small and very slender. Lateral appendages or "feet" of the first six setigerous segments similar in structure but more prominent than the following ones, from which they also differ in having the ventral cirrus well developed, long and tapering, but shorter and thicker on the first segment than on the five following. Those of the first pair have a stout stalk, which terminates in a small, bluntly rounded setigerous lobe, with a long, slender, subterminal cirrus-like lobe above, longer than the stalk; dorsal cirrus arising from near the base, longer and more slender than the terminal cirrus; branchial filament simple, long and very slender, about equalling the dorsal cirrus and united to it above its base; ventral cirrus ovate, tapering, blunt, arising from near the base. The second pair of feet are similar to those of the first, except that in the largest specimens there are two branchial filaments, and the ventral cirrus is

longer and more slender. The 3d, 4th, 5th and 6th pairs have essentially the same structure, but the ventral cirrus becomes gradually longer to the 6th, where it is longer than the stalk and nearly equal to the terminal cirrus. The succeeding feet are much shorter; the ventral cirrus is a mere conical papilla, which soon disappears; the terminal cirriform lobe becomes smaller and disappears after the 10th pair; the branchial filament becomes larger and longer to the middle region, where it exceeds in length half the diameter of the body, while the dorsal cirrus at the same time becomes smaller and shorter, until it is less than one-fourth the length of the branchia.

The setæ of the anterior feet consist of slender, acutely pointed, curved ones, mixed with much stouter, blunt pointed compound ones; farther back there are two fascicles of more slender acute setæ, and in the lower bundles a few long, stout, bidentate hooks, with a thin, rounded, terminal expansion.

Color, in alcohol, pale yellowish white, but everywhere very brilliantly iridescent with opaline lustre and colors.

Length, 3 to 5 inches; diameter, ·10 to ·15 of an inch (2·5^{mm} to 4^{mm}).

Near St. George's Bank in 110 and 150 fathoms, common; off Casco Bay, 30 to 94 fathoms, common; Jeffrey's Bank, 79 to 105 fathoms. Abundant at all the localities, on muddy bottoms, in deep water, in the Gulf of Maine.

The name "Nothria" was substituted for *Northia* (Johnston) by Malmgren for reasons that are scarcely sufficient. The latter name was, however, previously in use for a genus of shells (Gray, 1847), and must be rejected on that account.

Ninoë nigripes Verrill. (Plate 3, figure 5.)

First Report of Commissioner of Fish and Fisheries, p. 595.

Body elongated, slender, broadest a short distance behind the head, at the middle of the branchiferous segments. Head depressed, elongated, conical, blunt at end, about twice as long as broad. The branchiæ are represented on the first two setigerous segments by a short, flattened lobe, arising from the outer and posterior face of the setigerous lobe. On the two following segments the lobe is divided into two or three parts; on the fifth there are usually three, more elongated, round, and more slender branchiæ, which increase in number and length on the succeeding

segments until there are five, six, or more long, slender branchial filaments, which arise from the posterior face of the setigerous lobe, and diverge, forming a somewhat fan-shaped or digitate group; at about the twenty-fourth segment the number rapidly diminishes, and after the twenty-seventh or twenty-eighth there remains but one small branchial process. The setigerous lobe is prominent, obtuse, turned forward. The setæ are numerous on the branchial segments, and rather long, of various shapes, but mostly bent, with an acute lanceolate point; posteriorly they are shorter and fewer, and mostly slender, margined uncini, with hooks at the spatulate end. Body flesh-color; the setæ dark, often blackish; branchiæ bright red. Length of broken specimens, 20^{mm} to 50^{mm}; breadth anteriorly, 2^{mm} to 3^{mm}.

Vineyard Sound and Buzzard's Bay, and waters outside, in eight to twenty-nine fathoms, mud; Casco Bay, ten to sixty-eight fathoms; off the coast of Maine, at various depths to 107 fathoms.

Lumbriconereis obtusa Verrill, sp. nov.

Body slender, terete, tapering posteriorly, strongly annulated. Head nearly as broad as the body, obtusely rounded at the end. Lateral appendages prominent, bilobed, the posterior lobe longer and tapered; the anterior one is short and obtusely rounded. Near the posterior end the appendages are longer than the rest. The first twelve to fourteen segments bear fascicles of rather long setæ of three forms; those of the first three being shorter and less developed; on the fourth to twelfth segments the fascicles contain four to six setæ, of which the two or three upper ones are three or four times as long as the appendages, long, lanceolate, bent and flattened in the middle, with a long tapering tip; two are long slender uncini, narrowly margined and bent toward the end; and one is long and slender, with a very slender setiform tip. From about the fourteenth to about the twenty-fourth segment, the fascicles consist of one long slender seta, with two or three uncini, which are shorter and have more broadly margined tips than those of the preceding segments. On the succeeding segments the slender setæ disappear and two or three uncini remain, similar to the preceding ones, but gradually decrease in length posteriorly. Color of skin bright light green, the interior bright orange-red, showing through the integument. Length about 1 inch; diameter ·03 of an inch (·75^{mm}).

Casco Bay, three to ten fathoms, muddy and sandy bottoms.

Anthostoma acutum Verrill.

Op. cit., p. 599.

Body long and quite slender, tapering most toward the head, and very gradually posteriorly. Head very acutely pointed, with two rather indistinct reddish spots above, resembling imperfect ocelli. The branchiæ commence at the eleventh setigerous segment as small dorsal papillæ, and become prominent on the thirteenth; on the succeeding segments they become long and ligulate. Anteriorly the feet are represented by an upper ramus, consisting of a very small tuft of setæ, with a very small papilliform lobe above it; and a lower ramus, consisting of a small prominent papilla, with a fascicle of slender setæ, much larger than the upper one. On the fourteenth and succeeding segments the dorsal cirrus of the upper ramus becomes longer, more slender and ligulate. On the fifteenth segment a small, short, rounded ventral cirrus appears on the lower ramus, and farther back it becomes larger and more prominent, and the setigerous lobe becomes bilobed. Anal segment rounded, obtuse; cirri long and slender. Color light red. Length up to 40^{mm}; diameter, $2{\cdot}5^{mm}$.

Off Gay Head, nineteen fathoms, soft mud; also from the deeper parts of Vineyard Sound; Casco Bay, eight to thirty fathoms.

Praxilla zonalis Verrill. (Plate 5, fig. 4.)

American Journal of Science, vol. vii, p. 505, plate vi, fig. 2, May, 1874.

Body composed of about twenty-five segments, exclusive of the cephalic and anal; of these twenty-two bear fascicles of setæ; two ante-anal segments are destitute of setæ, and each of these is more or less distinctly biannulated, so as often to appear like three or four distinct segments. Cephalic lobe with a rather low and broad median ridge, prolonged in front of head; the end depressed, tapering, obtuse; narrow, lateral, parallel fossæ bound the median ridge; the head is bordered by a thin moderately elevated fold, continuous on each side, or with a very slight, scarcely distinct notch, behind the middle; a slight posterior notch, where the two lateral lobes unite.

The first three setigerous segments are, in ordinary states of contraction, about equal in length, rather longer than broad, tapering backward; the next four are nearly cylindrical, biannulated, in preserved specimens often as broad as long, more elongated when living; the seven succeeding ones are more elongated, nearly

Plate 5.

Fig. 1.

Fig. 2.

Fig. 3.

Fig. 4.

Fig. 5.

Fig. 6.

Fig. 7.

Fig. 1.

Fig. 2.

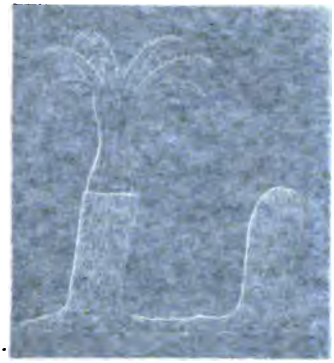


Fig. 6.

Fig. 4.

Fig. 5.

Plate 5.

Fig. 1.

Fig. 2.

Fig. 3.

Fig. 4.

Fig. 5.

Fig. 6.

Fig. 7.

Plate 6.

Fig. 1.

Fig. 2.

Fig. 3.

Fig. 4.

Fig. 5.

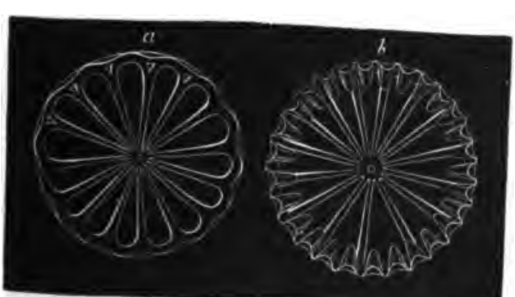


Fig. 6.

cylindrical, and all similar; the following ones become smaller, more elongated, and more or less constricted anteriorly; the last two setigerous ones are shorter than those that precede them. The first three setigerous segments bear an upper fascicle of slender setæ, and a single small, spine-like seta below, on each side; the succeeding segments bear a larger upper fascicle of slender setæ, and a row of numerous uncini below. Anal segment more or less funnel-shaped according to the state of expansion, bordered by a circle of sixteen to twenty slender, subequal papillæ, with one on the ventral side longer, and sometimes nearly twice as long as the rest; occasionally smaller papillæ alternate irregularly with the larger ones, and the ventral papilla may be but little longer than the rest. Color, generally light orange-yellow, slightly iridescent anteriorly, and with bright red vessels; an ill-defined band of dark red covers the fourth, and the posterior part of the third segment; more clearly defined bands of bright red occupy the posterior half of the fifth, sixth and seventh segments, the last being twice as broad as the two preceding; posterior to this the surface is more or less specked with red, and the convoluted bright red dorsal vessel is very distinct; uncigerous lobes pale yellow, centred with yellowish brown or reddish brown. The eggs are pale yellow, regularly oval or elliptical. They were discharged July 29th. Length about two inches, or 50^{mm}; diameter about $1{\cdot}25^{mm}$.

Casco Bay, eight to twenty fathoms, sandy and muddy bottoms.

Ancistria capillaris Verrill, sp. nov.

Body long, very slender, terete, thickest anteriorly, composed of numerous segments. Head small, sub-conical, composed of two segments, depressed, the tip bluntly rounded and slightly turned up. A small proboscis is sometimes protruded forward from the mouth. The first four segments bear fascicles of several slender, acute, curved setæ, above and below; the succeeding ones bear transverse fascicles of elongated uncini, broadly margined on each side; farther back these become shorter and less distinct.

Body flesh-color, with red markings due to the circulating fluid. Diameter $0{\cdot}25^{mm}$ to $0{\cdot}50^{mm}$ (·01 to ·02 of an inch).

The tubes are long, capillary, unattached, tough, flexible, covered with firmly adhering grains of fine sand.

Casco Bay and off the coast of Maine, in thirty to one hundred and fifty fathoms; abundant on muddy bottoms.

Ancistria acuta Verrill.

American Journ. Science, vol. vii, p. 505, plate vi, fig. 3, May, 1874.

Body elongated, terete, slender, but stouter than the preceding, thickest anteriorly, composed of numerous short, distinct segments, of which the anterior ones are biannulated. Head conical, acute. The seven anterior segments bear fascicles of several long, slender, acute, bent setæ, both above and below. The succeeding segments bear fascicles of elongated uncini. Diameter of body, $0{\cdot}5^{mm}$ to nearly 1^{mm}.

Broad Sound, Casco Bay, fifteen to twenty fathoms.

ARENIELLA Verrill, gen. nov.

Head acute, conical, mouth beneath. Body slender, terete, composed of numerous similar segments, without any marked division into distinct regions. The upper fascicles on all the segments contain slender, acute, bent setæ, usually mingled with some of different forms anteriorly. The lower fascicles contain shorter, mostly simple setæ anteriorly, and bidendate uncini farther back.

Areniella filiformis Verrill, sp. nov.

Body long, slender, filiform, terete, of nearly uniform width, but sometimes thicker anteriorly, composed of numerous biannulated segments. Head small, acute. Mouth crescent-shaped, bordered posteriorly by the swollen buccal segment. The first seven segments bear three or four short, stout, obtuse setæ in the lower fascicles; in the upper fascicles, much longer and acute setæ, shortest and fewest in the anterior segments; part of these are long, slender, curved and tapering toward the tip, about one-third as long as the diameter of the body; and others are stouter, and only about half as long, spine-like, bent and mostly acute at tips, but sometimes bidentate; these are usually the lowest in each fascicle, but sometimes alternate with the longer ones. The eighth setigerous, and many succeeding segments, have upper fascicles nearly like those of the preceding ones, but with longer and more numerous setæ; the lower fascicles mostly consist each of two elongated, curved, obtuse, bidentate uncini. Pos-

teriorly the setæ of the upper fascicles become much longer and more slender, often exceeding the diameter of the body, and the fascicles are larger. Diameter about ·01 of an inch ($0·25^{mm}$).

Casco Bay; twenty to forty fathoms, mud.

Grymæa spiralis Verrill. (Plate 5, figure 5.)

American Journal of Science, vol. vii, p. 407, fig. 1, and plate 5, fig. 4, April, 1874.

Body long and slender, spirally coiled, composed of over 150 segments, of which about 120 bear fascicles of slender setæ. Branchiæ long filiform, two or three times the diameter of body, arising in three clusters on each side, easily detached and often partially absent. Setæ on the first six or seven segments a little longer than the following ones. General color dark red. Tube composed of firmly cemented mud and sand, coiled in a double spiral, the two halves revolving in opposite directions.

Off Casco Bay, in ninety fathoms, mud; off Grand Menan I., sixty fathoms; Jeffrey's Bank, eighty fathoms.

GEPHYREA.

Phascolosoma boreale Keferstein (?), Beiträge zur Anat. und syst. Kentniss der Sipunculiden, p. 206.

This species is rather short and thick, obtuse posteriorly, nearly smooth to the naked eye, and destitute of both hooks and distinct suckers, but the skin is minutely wrinkled transversely, and covered with almost microscopic slender papillæ, and is minutely specked with dirty yellowish brown; the retractile portion is more distinctly granulated anteriorly. The tentacles are rather numerous, small and simple.

Off Casco Bay, sixty-four fathoms; Cashe's Ledge, fifty to seventy-two fathoms; near St. George's Bank, 110 fathoms; Gulf of St. Lawrence (Whiteaves).

Phascolosoma cæmentarium Verrill.

First Report of U. S. Comm. of Fish and Fisheries, p. 627, plate xviii, fig. 92.

Sipunculus cæmentarius Quatrefages, Histoire Nat. des Annelés, vol. ii, p. 628, 1866. This is the *Sipunculus Bernhardus* of American writers, but not of Forbes. *P. hamulatum* Packard, Mem. Boston Soc., ii, p. 290, 1867, may be the same species. It is perhaps identical also with *Sipunculus capitatus* Rathke, Fauna Norwegens, p. 143, plate vi, figures 20–23, 1843.

Very common on the coast of New England, from Vineyard Sound northward, in 5 to 430 fathoms, in dead univalve shells.

Phascolosoma tubicola Verrill.

American Journal of Science, vol. v, p. 99, 1873.

Body versatile in form; in contraction short, cylindrical, oval, or fusiform, ·5 to one inch long, ·10 to ·15 in diameter; in full extension the body is more or less fusiform, gradually tapering anteriorly into the long, slender, nearly cylindrical retractile portion, which is longer than the rest of the body and bears, near the end, a circle of about ten to sixteen, simple, slender tentacles, beyond which the terminal portion is often extended into a short proboscis, with the mouth at the end; below the tentacles there is sometimes a dilation, but this is without special spines or granules, and like the rest of the retractile portion in texture. The posterior end of the body is bluntly rounded, and the skin is transversely wrinkled and rough, and covered with small, round, somewhat raised verrucæ or suckers, to which dirt adheres, and at the end nearly always bears from 3 to 8, small, but prominent, peculiar bodies, having a slender pedicel and a clavate or globular head; their nature is doubtful (they may be sense-organs, but should be examined on living specimens). At about the posterior third of the proper body is an irregular zone of numerous, dark brown, hard chitinous hooks, arranged in several rows, broad triangular in form, with acute points directed forward; among the hooks are also a few suckers; the middle region is covered with small, round, slightly raised suckers, which become much more prominent and crowded at the anterior end toward the base of the retractile portion, and have here the form of small, subconical, elevated warts, to which dirt usually adheres firmly; the retractile portion is covered throughout with minute conical verrucæ or papillæ, most prominent toward the base.

In many respects *P. cœmentarium* agrees very closely with this, but it has the posterior end much smoother, and with less conspicuous suckers; the hooks are not so numerous, less acute, and lighter colored; the anterior part of the body has smaller and less prominent suckers or verrucæ; the skin is lighter colored, thinner, and more translucent, and there is a zone bearing several rows of minute, slender, acute, chitinous spinules, a little below the tentacles.

Off Casco Bay, sixty to ninety-four fathoms; near St. George's Bank, eighty-five to one hundred and fifty fathoms.

TURBELLARIA.

Ophionemertes agilis Verrill. (Plate 2, figure 4.)

American Journal of Science, vol. vii, p. 45, plate vii, fig. 1, 1874.

Allied to *Tetrastemma*. Body slender, slightly depressed, with the sides well rounded, thickest in the middle, tapering gradually to the slender, obtuse, posterior end; head somewhat separate from, and wider than the anterior part of the body, changeable in form, often oval, sometimes sub-triangular, generally longer than broad, narrowed anteriorly, obtuse or slightly emarginate, with a terminal orifice. Eyes numerous, forming a long, crowded lateral row or group along each side of the head; the rows are simple and convergent anteriorly, posteriorly they become broad and double. Back of the eyes there is a curved transverse groove or furrow, crossing the back of the head. No lateral fossæ were observed. Color pale ochre-yellow; the intestine slightly reddish; the internal lateral organs lighter yellow, giving a reticulated appearance to the sides. Length 25^{mm} to 40^{mm}; $1{\cdot}5^{mm}$ to 2^{mm} in diameter.

Casco Bay, twenty to sixty-five fathoms; Bay of Fundy, forty to ninety fathoms.

Tetrastemma vittata Verrill. (Plate 2, figures 7, 8.)

Op. cit., vol. vii, p. 45, plate vii, figs. 3, a, b, 1874.

Body short and stout, obtuse at both ends, well rounded, little depressed; head not distinct from the body, obtusely rounded. Eyes four, small and not very distinct, the two pairs widely separated, the anterior ones near the anterior end, and nearer together than the others. A well-marked transverse groove or fold is situated between the two pairs of eyes, and extends around to the ventral side; proboscis-orifice terminal. Color of body dark olive-green, greenish brown, or greenish black, often with a light longitudinal dorsal stripe; head greenish, marked with six longitudinal white stripes or vittæ, which radiate from the terminal orifice and extend backward to the transverse furrow, which is bordered by a transverse band of white, often forming a whitish ring around the head; two of the vittæ are dorsal; two ventral; and one lateral, on each side; a less distinct median ventral one is sometimes visible. Length, 25^{mm} to 40^{mm}; diameter, 4^{mm} to 7^{mm}.

Casco Bay, three to twenty fathoms, on muddy bottoms.

Macronemertes gigantea Verrill. (Plate 2, figures 5, 6.)

American Journal of Science, vol. vi, p. 439, pl. vii, figs. 2, a, b, 1873.

Body much elongated, subterete, a little depressed, thickest anteriorly, gradually tapering posteriorly, becoming very slender toward the end. Integument very soft, secreting a large quantity of mucus. Head not distinct from body, obtusely rounded in front, with a terminal pore; upper surface with two longitudinal fossæ; below with two rather indistinct transverse grooves, or fossæ, in advance of the mouth. Ocelli numerous, arranged in six clusters; a pair of large clusters on the anterior lateral border of the head; a pair of smaller lateral clusters farther back; and a pair of small clusters on the dorsal surface, between the longitudinal fossæ. Color, when living, bright orange-red above, flesh-color below. Length, about eight feet, in extension; diameter, anteriorly, ·30 of an inch (7^{mm} to 8^{mm}).

Off Cape Elizabeth, sixty-eight fathoms, soft mud, Aug. 12.

TUNICATA.

Ascidia mollis Verrill. (Plate 1, fig. 5.)

American Journal of Science, vol. vii, p. 409, fig. 2, 1874.

Body large, hemispherical or subglobular, attached obliquely by the left side; integument rather thin, soft and somewhat translucent, with the surface nearly smooth, but more or less wrinkled. Color, pale olive-green. Branchial aperture near one end, large, slightly elevated, surrounded by eight obtusely rounded lobes; anal orifice placed to one side of the middle of the body, little elevated, relatively small, rounded in ordinary expansion. Diameter of body usually one to two inches.

Common in forty-eight to one hundred and seven fathoms, attached to bowlders in many localities off Casco Bay; off Manheigan I.; at Jeffrey's Bank; Cashe's Ledge, etc.

ANTHOZOA.

Cornulariella modesta Verrill. (Plate 6, figs. 2, 3.)

American Journal of Science, vol. vii, p. 40, plate viii, figs. 1, 2.

Allied to *Cornularia* and *Telesto*. Polyps tubular, rising from creeping stolons; the lower part of the polyp-bodies has the walls thickened and stiffened by large numbers of spicula, having interlocking branches or projections, and is more or less eight-ribbed

in contraction; upper part of body hour-glass shaped, flexible, translucent, whitish, with fewer white spicula, retractile into the lower part, the eight internal lamellæ showing through. Tentacles large, expanding about 6^{mm}, lanceolate, gradually tapering to the acute tips, flat above, with the short thick pinnæ arranged along the upper edges on the distal half; the lower side of the tentacles is rounded and more or less swollen toward the base. Color of stolons and base of polyps dirty yellowish or brownish; flexible part of polyps and the tentacles translucent white; the latter with central rows of white spicula. Height of polyps, 6^{mm} to 18^{mm}; diameter, 3^{mm}; distance between polyps, 6^{mm} to 25^{mm}; breadth of stolons, about 3^{mm}.

Casco Bay; Bay of Fundy, eighty to one hundred fathoms. Gulf of St. Lawrence, in 220 fathoms (Whiteaves).

Cerianthus borealis Verrill.

Op. cit., vol. v, p. 5, January, 1873.

Body much elongated, tapering gradually to the abactinal opening, the surface smooth but more or less sulcated longitudinally. Marginal tentacles very numerous and unequal, the inner ones longest, in the largest specimens 2·25 inches long, and ·12 in diameter at base, gradually tapering, acute; the outer ones 1 inch and less in length. Oral tentacles numerous, crowded in several rows, in the largest specimens about 1 inch long, slender, acute. Color of body olive-brown or dark chestnut-brown, sometimes pale bluish just below the tentacles; disk pale yellowish brown; space within the oral tentacles, around the mouth, deep brown, with lighter radiating lines; oral tentacles pale chestnut-brown; marginal ones deep salmon or yellowish brown, the longest usually barred transversely with six to eight dark reddish brown spots, each spot partially divided along the median line into two lateral ones.

The two largest specimens, dredged in twenty-eight fathoms, east of Grand Menan, by the writer, measured 5 inches across the disk and tentacles, but their bodies were mutilated. Entire ones of much smaller size were dredged by Dr. Packard and Mr. Cooke in 110 and 150 fathoms, soft mud, near St. George's Bank. The largest of these was eight inches long, and like other species of the genus, inhabited a thick, tough, felt-like, muddy tube.

Casco Bay, seven to ninety-four fathoms; off Seguin Island seventy-five fathoms, of large size (18 inches long, 1·5 in diameter, and 7 inches across the tentacles).

SPONGIÆ.

Leucandra cyathus Verrill, sp. nov.

Sponge deep cup-shaped or goblet-shaped, with a short, thick pedicel and a wide terminal opening, surrounded by an even, acute rim; walls of the sponge rather firm, moderately thin, finely porous; external surface even, sparingly hispid, with the short projecting points of scattered fusiform and tri-radiate spicula; internal surface finely porous, and roughened with small, short points of spicula, directed upward. The external wall is filled with an intricate net-work of moderately large, mostly tri-radiate spicula, part of which are sagittate, with a straight shaft, and two long, slender, widely divergent, slightly curved branches; partly regular, with the angles nearly equal; all have long, moderately slender rays, tapering regularly to a sharp point; in some, one ray is considerably longer than the others. A few straight, fusiform spicula, with acute tips, project from the surface; they are about as large as one of the branches of the tri-radiate ones. The walls of the irregularly divided radiating tubes are supported by the long, straight shafts of tri-radiate sagittate spicula, having their branches widely divergent, curved and mostly imbedded in the outer or inner walls, and usually about half as long as the shaft. The inner wall is supported by tri-radiate spicules, similar to those of the outer wall, and by quadri-radiate sagittate spicula, mostly smaller, and with unequal curved branches, the apical one short, projecting slightly beyond the inner surface, and directed upwards. Height of sponge, 20^{mm} to 25^{mm}; diameter of cups, 8^{mm} to 10^{mm}. Color pale yellowish white.

Casco Bay, off Witch Rock, fifteen fathoms.

Ascortis Clarkii Verrill, sp. nov.

Sponge forming long, slender, regular, subcylindrical tubes, either simple or sparingly branched, with smooth thin and delicate walls; terminal orifice usually small and simple, or surrounded by a short fringe of small spicula. The walls are composed of a close, irregular net-work of slender tri-radiate spicula, which are regular, with long, slender, tapering, subequal, acute rays; usually the angles are nearly equal, but some are more or less sagittate in form, with two of the rays widely divergent and slightly curved. Among the tri-radiate spicula there are many small, very slender, acute, fusiform ones, which are mostly less than half the diameter

of one of the rays of the former, and from one-third to two-thirds the length. Length of the sponge-tube, 15^{mm} to 25^{mm}; diameter, $0{\cdot}60^{mm}$ to $0{\cdot}80^{mm}$. Color pure white.

Quahog Bay, at low water, abundant.

This is the most delicate species of calcareous sponges found on our coast and is so translucent as to display very readily the form and structure of the minute zoöids, like those figured by the lamented Professor H. J. Clark in a closely related species (*A. fragilis*, var. *bifida* Hæckel). These can be easily made out even in alcoholic specimens, and are large enough to be visible with a one-inch objective. This species is readily distinguished from *A. fragilis*, both by its long, even, sparingly branched tubes and by having regular spicula instead of the irregular ones characteristic of the latter.

Leucosolenia (*Ascaltis*) *cancellata* Verrill, sp. nov.

Sponge massive, pyriform, hemispherical, subglobular, or irregular, consisting of an intricate mass of small anastomosing tubes, which are more or less coalesced; surface variously cancellated, consisting of small, irregular, mostly angular, deep depressions or pits, separated by thin rounded ridges. The thin walls of the tubes are supported by a net-work of rather small, regular, tri-radiate and quadri-radiate spicula, the two sorts about equal in size. The tri-radiate ones mostly have the rays and angles nearly equal; the rays being nearly straight, long, and tapering but little to near the ends, which are somewhat obtusely pointed; some of the spicula are broadly sagittate, with wide spreading branches. The quadri-radiate spicula have a small, short, acute, straight or curved apical ray, many times shorter than the others, which are similar in size and form to those of the tri-radiate spicula. Diameter of the sponge mass 6^{mm} to 30^{mm}; diameter of component tubes $0{\cdot}5^{mm}$ to 1^{mm}. Color yellowish white to brownish yellow.

Casco Bay, ten to sixty-four fathoms; Cashe's Ledge, fifty-two to seventy fathoms.

This species belongs to the genus *Ascaltis* of Hæckel, which contains the typical species of the old genus *Leucosolenia*.

EXPLANATION OF PLATES.

PLATE 1.

Fig. 1. *Octopus Bairdii* V., male; profile view, natural size.

Fig. 2. The same, dorsal view.

Fig. 3. *Entalis agilis?* G. O. Sars; lateral view of the soft parts, in extension, enlarged about four diameters.

Fig. 4. *Entalis striolata;* several views of animal, with the foot in different states of expansion; enlarged about one and a half diameters.

Fig. 5. *Ascidia mollis* Verrill; natural size.

Fig. 6. *Chelyosoma geometricum* Stimpson; natural size.

[The drawings are by J. H. Emerton.]

PLATE 2.

Fig. 1. *Gattiola cincinnata* Verrill; dorsal view; enlarged about five diameters.

Fig. 2. *Nephthys ingens* Stimpson; dorsal view of anterior part of body and proboscis; enlarged.

Fig. 3. *Ammotrypane fimbriata* Verrill; ventral view; natural size.

Fig. 4. *Ophionemertes agilis* Verrill; dorsal view; enlarged about two diameters.

Fig. 5. *Macronemertes gigantea* Verrill; anterior part of body and head; ventral view; natural size.

Fig. 6. The same; dorsal view.

Fig. 7. *Tetrastemma vittata* Verrill; anterior part of body and head; dorsal view; enlarged about four diameters.

Fig. 8. The same; front view of the head.

[Figures 5 and 6 were drawn by the author, the rest by J. H. Emerton.]

PLATE 3.

Fig. 1. *Phyllodoce catenula* Verrill; dorsal view of anterior part of body and head, and of the extended proboscis; enlarged about four diameters.

Fig. 2. *Proceræa gracilis* Verrill; dorsal view of head and anterior portion of body; enlarged about six diameters.

Fig. 3. *Nereis pelagica*, male and female; natural size.

Fig. 4. The same; one of the lateral appendages of the 54th segment; enlarged about ten diameters.

Fig. 5. *Ninoë nigripes* Verrill; one of the lateral appendages; greatly enlarged.

[Figures 3 and 4 are copied from Ehlers; the rest are by J. H. Emerton, from nature.]

PLATE 4.

Fig. 1. *Stephanosyllis ornata* Verrill; anterior and posterior portions; enlarged eight diameters.

Fig. 2. *Eulalia pistacia* Verrill; anterior and posterior parts of body; enlarged about four diameters.

Fig. 3. *Vermilia serrula* Stimpson; anterior part of tube and expanded branchiæ of an immature specimen; much enlarged.

Fig. 4. *Nothria opalina* Verrill; anterior portion; enlarged about five diameters.

[The figures were drawn by J. H. Emerton.]

PLATE 5.

Fig. 1. *Nereis virens;* head and anterior segments; slightly enlarged.

Fig. 2. The same; lateral appendages; enlarged four diameters; *a*, appendage from the 56th segment; *b*, from the 80th segment.

Fig. 3. *Enipo gracilis* Verrill; setæ enlarged 175 diameters; *a*, one of the inferior setæ of the lower ramus; *b*, one of the superior setæ of the lower ramus; *c*, one of the setæ of the upper ramus.

Fig. 4. *Praxilla zonalis* Verrill; anterior and posterior portions; enlarged about three diameters.

Fig. 5. *Grymæa spiralis* Verrill; lateral view of anterior portion; enlarged about three diameters.

Fig. 6. *Lumbriconereis fragilis;* anterior part of body and head, dorsal view; enlarged about six diameters.

Fig. 7. *Nephthys ciliata;* one of the lateral appendages; enlarged ten diameters.

[Figures 1, 2 and 7 are copied from Ehlers; figure 3 is from nature, by the author; the rest were drawn from living specimens by J. H. Emerton.]

PLATE 6.

Fig. 1. *Edwardsia farinacea* Verrill; lateral view; enlarged about three diameters.

Fig. 2. *Cornulariella modesta* Verrill; two of the zoöids, one in contraction; enlarged about four diameters.

Fig. 3. The same; some of the spicula from the integument of the body; enlarged.

Fig. 4. *Alcyonium carneum* Agassiz; three of the polyps; enlarged about ten diameters.

Fig. 5. *Oligotrochus vitreus* G. O. Sars; two of the plates from the integument of the body of a specimen dredged in 79 fathoms near Jeffrey's Bank; enlarged 140 diameters; *a*, a wheel with the rim not fully developed, but continuous; *b*, a wheel with the rim fully formed.

Fig. 6. *Chætoderma nitidulum* Loven; with the branchiæ retracted; enlarged about five diameters.

[Figure 6 was drawn by J. H. Emerton; the others by the author.]

ON THE ORIGIN OF SPECIES. By G. C. SWALLOW, of Columbia, Mo.

A large number of the cultivators of science have believed in the integrity of species. They have based their investigations on the hypothesis that certain organic beings are alike in all their essential characteristics; that each had a well defined beginning, will produce its kind, and that each series will maintain its identity indefinitely to the end. They have at the same time admitted that individuals may be somewhat changed by various causes, such as climate, food and habits, and that such changes may be fostered and transmitted, especially by man's care; that varieties with marked variations may be produced by special causes, but that when these causes cease and the original conditions are restored, the variations will rapidly disappear, and that the varying series will return more or less perfectly to the original stock.

But at the beginning of the present century, Lamarck, St. Hilaire, and a few other distinguished savans, were led by numerous facts to adopt and promulgate a theory of Development; that inorganic matter is developed into the lower orders of organisms, and these in turn are developed into higher orders until man is produced. Thus all species and orders of organic beings were brought into existence and developed by natural laws without the intervention of final causes.

The promulgation of this theory created a profound sensation, though the world was then absorbed by the most important political events of modern times. But Cuvier and others so successfully defended the immutability of organic forms, that nearly all scientific men continued to believe in the integrity of species, notwithstanding the rudimentary organs and other facts adduced by Lamarck in support of his development theory.

About the middle of this century the "Vestiges of Creation" appeared, reannouncing the Theory of Development and extending it far beyond the limits indicated by Lamarck. The work presented a formidable array of facts, carefully collected from all departments of natural science. This work led to many able and often repeated discussions of the theory, in which its opponents seemed to have a decided advantage in the argument, and the belief in the immutability of species held its position in the scientific world, though some doubted and entered upon a more careful examination of the subject.

Some ten years later, Mr. Charles Darwin and Mr. Alfred Wallace promulgated a theory accounting for the origin of species by variations produced in several ways, but more especially by *natural selection.* Mr. Darwin has sustained his theory by several very able works in which he has collected a vast multitude of facts from all parts of the world and from all departments of natural science. So strong has he made his position, and so profound has been the impression upon men of all classes, that most scientific men have more or less examined the theory in its new relations, and a great many naturalists have given to what is called "Darwinism" their tacit assent, and many others their active support. But Mr. Darwin wisely limits the effects of his theory. He admits the creation of primoidal beings, thus avoiding the weakest parts in the theories of Lamarck and the author of the "Vestiges," by leaving the little known region along the boundaries of the organic and the inorganic kingdoms out of the discussion. Meanwhile other diligent students of nature have pushed their investigations so far into these unknown regions as to become fully satisfied of the production of organic beings by natural laws.

Mr. Crosse announced the generation of new animals, the *Acarus Crossii*, by the agency of galvanism; though the force of his declaration was neutralized when others recognized, in the mites, which came trooping up the conducting wires, an old acquaintance, the *Acarus horridus.* But when Drs. Bastian and Child, and Prof. Haeckel, Mr. Herbert Spencer, and others, declare that the evidence of evolution covers the whole space from inorganic matter up to man, it becomes a matter of more serious import. We find the bases of our applied logic disappearing, and the old and long trusted dicta of scientific investigation swept away.

Harvey's declaration *Omne vivum ex ovo* is giving place to the opposite, *Nihil vivum ex ovo;* and the oft used dictum, "there is no beginning or change of existence without a cause," which has so often come to our aid when we came to the end of our knowledge, is rapidly becoming obsolete before the universal dominion of law.

When we had a million species and a long list of inorganic simples and a countless multitude of stars, the logician had a fine field for his final causes, but now when all are swept away, and all things are developed by natural laws, save the primoidal star dust or fire mist, that alone in all the wide universe admits the need of

final cause. But, doubtless, some ingenious yankee will soon make a telescope sufficiently powerful to dissolve all nebulæ and dissipate all evidence of fire mist and star dust, leaving nothing for all things to be developed from, and instead of proving *ex nihil nihil est*, we shall be compelled to adopt again the old faith *ex nihil omnes sunt.*

Few men, I apprehend, adopted the theory of Comte's Positive Philosophy, but if the views above quoted be correct, science will have demonstrated the principles upon which it is based, "the fundamental law of the development of the human mind." If, as Comte says, ignorance alone admit a necessity for final causes, and if the mind, when it arrives at a perfect knowledge of truth, will admit no final causes, and if this be the highest stage of man's development, the last end of the series which commenced with mere jelly speck or protoplasm, we must conclude we are fast approaching the end of our development, man's most perfect state. For the tendencies of the age to ignore final causes, simply because we see few necessities for them, must satisfy Comte himself.

Now all this sadly interferes with our long cherished views of science, and gives us many a sad twinge of heart-ache to part with the principles instilled into our minds by our teachers, the venerated fathers of American science, Cleaveland, Silliman, Hitchcock and Torrey.

But the votaries of science are not the only class who have had their most cherished opinions seriously jostled by zealous investigators who fearlessly express their honest convictions. We are now prepared to sympathize with the students of Homer who looked upon the Iliad as the greatest Epic, when Wolf and Heyne declared their model Iliad a mere patchwork, made up of the songs of strolling minstrels; and the votaries of Shakspeare, since Judge Holmes and others have proved Shakspeare was not written by Shakspeare, but by a disgraced jurist, who had small gift of poetry.

But we submit, and are ready to follow wherever the facts lead. It is, however, as Mr. Darwin says, difficult for us old men to give up our long cherished views, and it must not be deemed strange that we have difficulties still, and some points upon which we need more light.

It is my object, having presented the proposition as I understand

it, to state some of these difficulties without stopping to discuss the issues, for, as Mr. Darwin has well said, there is scarcely a subject upon which he relies to sustain his theory that does not furnish arguments for both sides of the question. I am thoroughly impressed with the idea that the innumerable facts adduced to establish this theory, save in a few cases, lead to no definite conclusions but to a mere balancing of probabilities. It also appears that the question at issue has not been stated with sufficient precision, and that the different parts of it have not been so carefully analyzed as to give a clear view of what changes are necessary at each stage of the progress from molecules to man.

A change which can be produced by merely enlarging a muscle is very different from a change which requires the addition of a new muscle, and one which requires the addition of a new bone to an osseous system is radically different from one that necessitates the giving a bone where none previously existed.

The fact that we can develop a race of long-tailed dogs into a race of bob-tails is no evidence, whatever, that the bob-tails can be changed into the long-tails, since one is effected by losses and the other must be by additions. It is far easier to lose than it is to gain.

Again, a change involving a modification of organs or properties already possessed can give no logical relations to one demanding the introduction of new organs and new faculties. The change of the reasoning powers gives no presumptive evidence that we can create the moral powers.

Between the lowest organism and man, there seem to be two very serious barriers; one of which appears utterly insuperable.

As the animal is higher than the plant, according to the theory plants must be transmuted into animals. But there are certainly no facts to show such a change possible. If we are referred to the lower orders where the plants and animals are so nearly alike and say the change may there occur, it leaves the affirmative without proof, and my objection still remains in full force.

We have facts to show we may change things, quality and principle, but none to show we can develop new ones. How you are to give a plant a nervous system and mental power does not appear. But it is said that we have proved so many changes to support the theory, you must accept it as a whole if there are some obscure parts. But the argument proves too much for Mr.

Darwin, as it would prove the development of matter into organisms as well as plants into animals. It is as easy to give life to molecules as it is to give mental powers to a plant.

As we have no facts to prove the development of a new faculty, so the facts cannot support a theory which covers such changes. The fact that you can change one animal into another only supports a theory of the change of animals, and not of plants into animals.

The other, and to me insuperable barrier, is the change of the lower animals into man. So far as the physical nature is concerned it might be possible, but in the highest degree, improbable, as no changes so radical have been observed. But when you say the intellectual powers of a monkey are developed into the human mind, the facts adduced have no relevance to the case. As was said before, the facts which prove the change of an animal into an animal, are no proof of a change of a brute into a human, nor of any theory which covers such a change. What powers of the monkey will give the moral powers of man?

Some will say that a savage has no more moral sense than a monkey. Then he is not a man, and the impassable barrier is between the savage and man, and not between the monkey and the savage. Somewhere you must add the moral power, if the theory be made to cover the human race.

Man also has a religious or superstitious element, as it is called by some, which is radically and totally different from any mental faculty in a brute. Hence there can be nothing in a brute to be developed into this faculty of man. But some say the religious element is a product of education. Comte, however, declares the exact contrary, the more ignorant the more superstitious. Certainly no intellectual state is more universal. Hence in making a man it must be provided for. I can conceive it possible to make a prophet out of a man, or a monkey, if need be, for he has mental powers that give him a knowledge of future events, and those faculties may be so improved as to comprehend all the future which is dependent upon fixed laws. But when we attempt to make a monkey recognize and fear the unknown, I find no germ or spark of an intellectual faculty in all the brute creation to begin with or to work upon. Take the intellectual senses, the powers of perception and conception, and develop them until they are as perfect in the monkey as Milton supposes them to be in the highest

Archangel, and they will still give nò intimation of the unknown. I have found no facts to indicate that such a change is possible.

We have a tolerable history of man ever since he has occupied the earth, and we may date his introduction near the close of the Tertiary or the beginning of the Drift period. Since then there has been time enough for any possible departure from original types. The advocates of the development theory admit the time since man's appearance to be not less than 240,000 or 500,000 years.*

That man lived in the Tertiary period is scarcely possible; for if his implements and remains were not obliterated by the powerful agencies of the Drift, there can be no reason why they should not have been preserved in the quiet times of the Tertiary, in which we find the remains of so many thousand plants and animals. We may safely conclude then that in the Drift we have man's earliest history. From this history we have a tolerable view of his form, habits, implements, habitations, burial-places, altars and sacrifices. And yet no one has claimed that we find any more evidence of the monkey among these primeval men than we do among the present races. The evidence on this point is conclusive. The oldest skull as yet found in Europe, about which there has been no doubt that it belonged to the age of extinct mammalia, the oldest of human remains, is simply a good Caucasian skull, and Prof. Huxley says, "there is no mark of degradation about any part of its structure. It is a fair average human skull which might have belonged to a philosopher."

Again the oldest skull found in America, so far as I know, about which there can be no question that its possessor was contemporary with the early mound builders, the elephant and mastodon, was found in a large mound in New Madrid county, Missouri, inclosed in an inverted earthen pot, resting upon the ancient dirt floor in an apartment of the mound which contained the altar and the charred remains of many victims. The mouth of the jar was so small the skull could not be removed whole. This skull was taken out in the presence of several gentlemen, from a depth of thirty feet below the undisturbed surface of the mound which was covered with a vegetable soil some two feet

* Mr. Croll, from astronomical calculations, makes the drift 240,000 years old, and its duration 160,000 years; Lyell from geological data makes the duration of the period above 224,000 and the age of drift at least 500,000 years.

deep, and on which were growing the older trees of a primitive forest, and stumps and fallen logs still older, were decaying. This precious relic of the earliest Americans is small, perfectly preserved, thin, of fine texture, oval rather than elliptical. I desired to show you this skull, but did not dare to risk its transportation. This mound was built on a second bench of the Mississippi, and about six feet of alluvial matter has been deposited since it was deserted. In the bank of a creek near, and apparently in the same formation that had been deposited around the mound, was found the tooth of a mastodon.

We opened another small burial mound near the one just described. It gave the same indications of antiquity. In it we found that many bodies had been deposited on the ground floor, several feet below the surrounding surface, but nothing remained save a dark stain and some gray calcareous powder, showing where dust turned to dust, and some enamel of the teeth. In this mound we also found a great many curious earthen vessels ornamented with plastic representations of animals and women. Of the latter some few represent the whole body, others the head and bust, and others the head only. These heads and faces represent a race as highly developed as the average Mongolian or the best developed Indian tribes.

I will assure you there is nothing in all these representations of humans and animals to remind you of the monkey but the arms of one of the women, and even they, though very different from the arms which art has given Mother Eve, are still a very exact representation of the long lean arms of the Malaysian women.

Other skulls of inferior structure and great antiquity have been found, but absolutely nothing to show that man was less developed then than now.

The historical record then gives us no indication of man's physical development from the monkey even during the 500,000 years he is supposed to have lived upon the earth.

But Mr. Darwin appeals to the illimitable geological cycles. But if a monkey is to be developed into a man, and we find that man has made little progress and the monkey less, during the vast periods of the Quaternary and recent ages, how long will it take to fill the wide gap between them?

Prof. Huxley has well but modestly answered this question. The advocates of progressive development must look for man's

primoidal stock in an epoch more distant from the tertiary than the tertiary is from the present, and that will carry his beginning beyond all monkeys and beyond all mammals, and he will be compelled to start from a reptilian or a fish. As much therefore as we gain in time we lose by beginning lower on the development scale.

There are therefore, two insuperable objections to the development of the monkey into man.

1st. The monkey had no rudiments of a moral sense or anything kindred to it, which could possibly be developed into man's moral nature.

The whole theory of development by natural selection is based upon like producing like. No natural selection ever could have produced a race of Retrievers had not some dog learned to retrieve, that he might be selected to propagate that race.

There is therefore no possibility of making a moral being out of a monkey by natural selection, unless some monkey with a moral sense can be found upon which to operate. Without this not a step can be made by natural selection.

2d. The facts in man's vastly long history fail to show even the slightest probability that the physical monkey was developed into the physical man.

If then, as scientific men, we follow where the facts lead and nowhere else, man must be dropped from the series before the theory can be accepted as true.

Like Mr. Darwin we must also admit organisms to start with.

Again the theory will be relieved of a serious difficulty by not requiring the change of plants to animals. It is quite as simple to suppose each comes from its own peculiar primoidal germs.

With some few modifications of this character, the development theory is relieved of its most serious difficulties.

Mr. Darwin has much confidence in the changes produced by domestication to establish his theory. His book is rich in interesting and instructive facts, but the facts do not carry the same convictions to all candid reasoners.

The facts incident to domestication are, in some respects, very valuable, since much greater changes are produced by the aid and skill of man than in the state of nature. Yet these changes cannot have the same value in determining the question at issue, since nearly or quite all the species have been produced in a state

of nature and under very different influences. Even if we give these changes all the force of natural developments, they still fall short of any conviction stronger than possibilities; as no species has been produced in all the thousand years of the trial. Cuvier's argument, from the animals and plants found embalmed in the ancient Egyptian tombs, more than neutralizes all the convictions from modern changes. Add to this the argument that is coming down from the prehistoric ages, and the negative becomes very strong. If in these many cycles man, with all his skill, aided by all climates, soils, food and varied habits, has not produced a species, when will he be able to do it?

Then, again, the universal tendency to return to original forms, when left to nature, makes it very improbable that such changes would occur in nature. It shows at least that there is no strong tendency to depart from original types.

The hog has been greatly changed by domestication, and yet when left to himself, he soon returns to the original type.

During the late war many hogs, some of the most improved breeds, were turned loose and left to shift for themselves. Three years after I found them possessing all the physical characteristics of the wild boar of Europe. This was especially true of the younger members of the herds.

Since such is the tendency with all animals and plants, it seems to indicate a natural stability of original types.

The American bison furnishes a very interesting example of changes produced by the physical structure of the regions they occupy. There are several well-known herds which range in certain wooded and high regions of the Rocky Mountains. These herds never come down to the plains. They leave their peculiar haunts only when driven down by excessive snows. They then remain among the foot-hills until the snow permits their return to their mountain fastnesses. How long these herds have occupied these places no one can tell, but long enough to produce such changes as well-known laws would indicate. They are smaller, have finer hair and darker color, and have more activity and sprightliness than their kindred of the plain. But it would be safe to predict a rapid disappearance of all these variations, should they be driven out to feed in the broad level prairies. The changes in these mountain bison are as great as the laws lead us to suspect, should they remain in their present homes indefinitely.

Should they migrate, they can find no possible location that would increase their variations; each new place would turn them back to their normal types. There are some important facts pertaining to the distribution of the American bison, showing he has limited capacities for migrations. All the facts known of the above-named mountain herds show they confine themselves to very limited areas. They never go beyond the limits of a cluster of spurs or a range of peaks, and hunters seldom fail to find them in a single day.

Benton says that "Buffaloes are the best engineers." They show great skill in selecting routes and unflinching perseverance in filling up chasms and quagmires with their own bodies. But they seldom cross the Rocky Mountains, though his trail leads hard by passes over which, unimproved, one could drive his carriage. The numerous skulls whitening along the Deer Lodge Pass, and down the valleys of the Silver Bow and Deer Lodge towards the Columbia, show that multitudes once crossed and perished. Why? Their annual migrations north through the Bad Lands, and across the Missouri, are obstructed by obstacles a thousand-fold more formidable so far as we can now see. There can be then no topographical reason why they may not cross the Rocky Mountains, and there must be some cause not as yet understood. The skulls over the Deer Lodge Pass, and beyond in the Silver Bow, prove that they did cross once at least, and that thousands of them perished and have left no representatives on the western slope.

These, and other facts connected with the American bison, show his migrations to be limited, and that nothing but the great Yellowstone Park can save him from extinction. There is no hope of a new species even from the mountain variety. In this connection we may ask why the elephant and mastodon died out on this continent during the terrace period? They had a genial climate, abundant forage, and none to make them afraid, and yet they perished miserably, putting an end to the most important dynasty on the continent.

Hybrids have played an important part in the discussion of this theory. Those produced in cultivation are made most prominent; whereas those occurring in the wild state ought to give us more reliable data for deductions. The fact that the wild hybrids are comparably few should caution us against giving the artificial ones too much prominence. Hybrids are very closely connected with our theory by two recognized facts:

1st. As a rule hybrids are barren, especially those produced in the natural state.

2d. The few fruitful hybrids usually manifest a tendency toward one or the other of the parent species.

We have a good illustration among our American oaks.

The Bartram oak was doubtless a hybrid of *Q. phellos* and *Q. tinctoria* or *Q. coccinia*. This oak was fruitful, and all the trees known as grown from its seeds are, according to Nuttall, well marked *Q. phellos*, showing an entire return from a variety so marked as to be pronounced a species by Micheaux, in the first generation.

Another hybrid called Lee's oak, and similar to Bartram's, was discovered near Cincinnati, and still another by myself near Boonville, Mo. These are doubtless hybrids of *Q. imbricaria* and *Q. tinctoria* or *Q. coccinia*. These hybrids must be very rare, though the parent species grow together over vast areas of our country. The hope of a species from the interesting Bartram oak, or even a healthy variety, has been destroyed by the death of the founder of the line, and the return of the offspring to one of the parent species. We may expect Lee's oak and my own to perish in their efforts to found a dynasty.

I once discovered the most beautiful of *Trilliums*. It was new, and it was my first chance for immortality. I named it *Cleavlandicum*, and sent it to Dr. Gray and all the botanists. But Dr. Gray's science detected the pretender, melted the wax from my wings, and let me down into the sea of despair. The shock gave resolution. The plants were distributed to the best cultivators. I watched over them, determined to make a species, with as much care as Darwin would over a hybrid between a Chimpanzee lady and a Bushman. All in vain. That species died out too.

My experience in wild hybrids is not such as to give me much confidence in their ability to found species.

The theory implies development in the ascending rather than in the descending scale—up from a Protozoan to man—contrary to the common opinion that the downward is the easy sliding scale. Among all animate things, the changes are as often downward as upward. This is especially true of cultivated species. The cereals, fruits, dogs and horses, all deteriorate, unless special efforts are made to keep them up.

Of fossil species, where we can trace them from the beginning

to the end, it is doubtful whether they improve. Genera, families, natural orders, and classes in the animal kingdom do as a whole improve for a time and then degenerate and perish miserably. The genus Cyrtia is the only exception remembered. It terminates with one of its noblest species. *Lingula*, *Terebratula* and *Rhynchonella*, which have lived from the lower silurian to the present, all improved through long cycles and thence deteriorated down to the present.

The same law seems to have pertained in the human family. Races, nations, clans, and families rise and fall according to the same law. The examples are too numerous and too familiar to need specifications. The only important exceptions are such as have had important external aids, or such as have not yet completed the usual destined courses. Yet, in nearly all, the indications of decline are obvious, while the others are showing no important departures from the normal stock.

TITLES OF COMMUNICATIONS.

THE following titles of papers read in Section B include those accepted by the committee for publication in full, but of which the authors have failed to send copy, as well as those which the committee decided should be printed by title only:

ARCHITECTURE OF THE AMERICAN ABORIGINES. SECTION I, ARCHITECTURE OF THE NORTHERN AND PARTIALLY VILLAGE INDIANS. SECTION 2, ARCHITECTURE OF THE VILLAGE INDIANS OF NEW MEXICO, MEXICO, AND CENTRAL AMERICA. By L. H. MORGAN, of Rochester, N. Y.

RELATION OF DENTALIUM. By EDWARD S. MORSE, of Salem, Mass.

ON THE AGE AND STRUCTURE OF THE CINCINNATI ANTICLINAL. By J. S. NEWBERRY, of New York, N. Y.

ON SOME PALÆOZOIC FISHES FROM THE ROCKS OF OHIO. By J. S. NEWBERRY, of New York, N. Y.

ZONES OF PARALLEL LINES OF ELEVATION IN THE EARTH'S CRUST. By ANGUS ROSS, of Halifax, Canada.

ON THE MARBLE DEPOSITS OF POTTSFORD, VERMONT. By J. S. NEWBERRY, of New York, N. Y.

EXHIBITION OF CRYSTALS OF SAPPHIRE FROM CEYLON, WITH BRIEF REMARKS ON THEIR FORMATION. By A. C. HAMLIN, of Bangor, Me.

EXHIBITION OF A COLLECTION OF GEMS, WITH BRIEF REMARKS. By A. C. HAMLIN, of Bangor, Me.

THE SALT DEPOSITS OF ONTARIO. By T. STERRY HUNT, of Boston, Mass.

MEANS OF DETERMINING THE STRATIGRAPHICAL ORDER OF SEAMS OF COAL IN OHIO, KENTUCKY, ETC. By E. B. ANDREWS, of Lancaster, Ohio.

CONCERNING HYALONEMA. By SAMUEL LOCKWOOD, of Freehold, N. J.

ONE MEANS OF DISTINGUISHING BETWEEN VEGETABLE AND ANIMAL LIFE. By T. S. LAMBERT, of New York, N. Y.

NATURAL FEATURES OF THE UNITED STATES NATIONAL PARK IN THE ROCKY MOUNTAINS. By JOSIAH CURTIS, of Washington, D. C.

ANIMAL ORGANOLOGY. By THEO. C. HILGARD, of St. Louis, Mo.

SOME BOTANICAL CONTRASTS OF PORTLAND WITH NEW YORK CITY. By JAMES HYATT, of Stanfordville, N. Y.

ON SPIDERS. By W. L. COFFINBERRY, of Grand Rapids, Mich.

EXHIBITION OF MARL FOSSILS FROM NEW JERSEY, NEAR THE COAST. By LEWIS FEUCHTWANGER, of New York, N. Y.

EXECUTIVE PROCEEDINGS

OF

THE PORTLAND MEETING.

HISTORY OF THE MEETING.

THE Twenty-second Meeting of the American Association for the Advancement of Science was held at Portland, Maine, commencing on Wednesday, August 20, 1873, and closing on the following Tuesday.

One hundred and ninety-five members signed the register, but this does not represent the full number in attendance, as it is known that many members who were present and paid their assessments neglected to sign the register. One hundred and ten new members were elected, of whom ninety-seven have paid the admission fee and assessment for the meeting, and their names have been incorporated into the list of members. One hundred and fifty-seven titles of papers were entered on the general list: of these, three were afterwards withdrawn by their authors; eight did not pass the Standing Committee, owing to the non-compliance of the writers to the rule requiring either the paper or an abstract to be sent in; two papers were referred to be read in General Session; sixty-nine were assigned to Section A, and seventy-five to Section B. Most of the papers referred to the sections by the Standing Committee were allowed a place on the daily programme.*

* The committee refused to accept for publication a few of the papers read, on the ground that they had already been printed. The committee would be relieved of some unpleasant work if it were more generally known that the publication of a paper in any form, before presenting it to the Association, would be considered under precedent, though not under rule of the Association, as practically excluding it from the consideration of the committee.

While mentioning the papers read before the Association I wish to call attention to the great loss which is annually experienced from the present inability of the Association to employ official phonographic reporters to write out the discussions which

The rooms in the City Building, placed at the disposal of the Association by the City Government, were very convenient and furnished, under one roof, all the accommodations desired for general and sectional meetings and committee rooms.

The Standing Committee held its preliminary meeting on Tuesday evening, the 19th of August, and during the session regular meetings were held from nine to ten o'clock, A. M. daily. Two special meetings of the committee were also held.

The Twenty-second Meeting was regularly organized in General Session at ten o'clock, A. M., on Wednesday, August 20th. In the absence of President Smith, and Vice President Winchell, Professor Lovering, the President elect, took the chair. After a few remarks by the President, prayer was offered by the Rev. Dr. Hill of Portland, who afterwards addressed the Association in behalf of the Committee on Reception.

President Lovering then addressed the Association as follows:

GENTLEMEN AND LADIES OF THE AMERICAN ASSOCIATION FOR THE ADVANCEMENT OF SCIENCE:

I know that you must regret that the distinguished member from Kentucky who presided over your deliberations, last year, with exceeding grace and dignity, is now absent in Vienna, serving science and his country in another capacity, instead of being present with us on this occasion; and certainly no one can regret his absence so much as I myself do. Were he with us, I am sure that he would heartily and happily discharge the duty, which, of late years, has been assigned to the retiring President, of congratulating the members of the Association on another of their annual gatherings, and organizing the business of a new meeting. I am no orator as he is: and you may sadly miss the ready and persuasive words which you have been accustomed to hear from the chair.

In fully surrendering, as I have now done, the office and the duties of your Permanent Secretary, which I have sustained dur-

take place, many of them of great importance and often placing a paper that has been read in a different light from that in which it appears when printed without the discussions, and it is greatly to be hoped that the means may soon be secured by which this very desirable end may be accomplished. Mr. Wheildon has alluded to this and other matters in a communication which he has sent to the office of the Permanent Secretary since the meeting, and as it contains views on a number of points of interest to members of the Association, it is at his request printed as an appendix to this history of the meeting.

ing fourteen meetings of the Association, I feel a great burthen removed from my shoulders which pressed heavily upon them not only at the time of our annual meetings, but during the whole year, and which has prevented me from contributing as largely as I could wish to the scientific wealth of the Association. Nevertheless, my heart compels me to say that my old office brought me into intimate relations with the members, of so agreeable a nature that I have been slow to relinquish them, and your kindness and forbearance, uniformly extended to me, have made my yoke easy and my burthen light. To the same kindness and forbearance I am indebted, and not to any scientific merits which I can claim, for the opportunity I now enjoy of retiring from the position which I held so long, through that dignified and ornamental portal over which is inscribed *President of the Association;* and which has been trodden by illustrious predecessors. I can sincerely congratulate you on the opening of a new era in the business of the Association, now that the duties of Permanent Secretary are transferred to younger and stronger shoulders, full of hope and vigor, and eminently fitted to bear even their multiplied weight.

I remember on this occasion that if the age of this Association is to be measured by the number of its meetings, it is twenty-one years old. It has survived the feebleness of infancy; it has outlived the perils and the inexperience of youth, and is of age. Now that it has become a man, we may demand of it that it put away childish things, if there have been any such in its former proceedings. We fondly trust that its past career has not been useless and we hope that it may exhibit in the future a still severer science and a higher wisdom. May the years of its manhood be begun and continued in such a way that its old age and decline will never come!

We have listened, with great interest and satisfaction, to the statements which have been made by the Rev. Dr. Hill, in behalf of the Local Committee and the citizens of Portland, and we deeply feel that the disinterested zeal displayed by them in providing for our comfort and pleasure, and in anticipating all our wants, while exciting our heartfelt gratitude, can only be repaid by an equal zeal and disinterestedness on our part in the cause which has brought us together and which can alone justify the trouble which we have given to them.

The usual business was then accomplished, including the report of the General Secretary, the election of six members to the Standing Committee, and the election of new members.

The Permanent Secretary read brief notices of the following members, information of their decease having been received since the last meeting.

Prof. John B. Perry, of Cambridge, Prof. John F. Frazer, of Philadelphia, Dr. Henry C. Perkins, of Newburyport, Prof. James Henry Coffin, of Easton, Pa., Dr. John Torrey, of New York, Miss S. L. Blatchley, of Chicago, Prof. Wm. S. Sullivant, of Columbus, Ohio, Judge Thomas Belden Butler, of Norwalk, Conn. Col. John Wells Foster, of Chicago, Dr. G. A. Maack, of Cambridge, Mr. Mark Fisher, of Trenton, N. J., Mr. Isaac Ferris, of New York, Mr. J. O. Noyes, of New Orleans. Of these, the names of Torrey, Foster, Coffin, Frazer and Perkins will be found enrolled as original members, and Professor Torrey and Colonel Foster as having been honored with the highest gifts of the Association.

On the recommendation of the Standing Committee, a committee was appointed to report on a revision of the Constitution. The Session then adjourned to meet in Sections. The sections, A and B, were at once organized and several papers were read.

In the evening a formal reception of the Association by the citizens took place in the City Hall; the Hon. George P. Westcott, Mayor, in the chair. The Hon. Benjamin Kingsbury, Jr., Ex Mayor and chairman of the Local Committee, gave the following address of welcome:

MR. PRESIDENT, LADIES AND GENTLEMEN OF THE ASSOCIATION FOR THE ADVANCEMENT OF SCIENCE:

The agreeable duty of tendering to you this public expression of the cordial good will of the citizens of Portland towards you personally, and your distinguished organization, has been assigned me by his honor, the Mayor, and the Local Committee.

During the long period of your existence as an Association one emphatic word has been the key-note of your reception wherever you have held your sessions, and that word is WELCOME. I would that I could find some other equally expressive word to indicate the sentiment of our citizens. But though our grand and flexible and copious language ordinarily affords a broad field of expression,

I am nevertheless remanded back to that old fashioned and time-worn word.

I therefore, Mr. President and Ladies and Gentlemen, extend to you in behalf of Portland, its citizens, its women as well as its men, its old men and children, its young men and maidens, a cordial welcome to our city, in no formal and perfunctory sense, but genuinely from our hearts.

We deem the assembly of your body, in our city, composed as we know it to be, of the profoundest students and best educated men of our country, as among the highest honors ever conferred upon Portland, and we now and here thank you for it.

The work of your Association is not unknown to us. You have remodelled and are remodelling the text books of science and making them enticing to youthful minds as well as to those of more maturity.

You are, by your straightforward and diligent searches after truth, wherever it may be found, and thrusting aside preconceived ideas and ancient traditions, working a wholesome influence upon the thought of all classes of society, thereby banishing the haughty pride and self-satisfaction of prejudice, and making men humble with the humility, not of superstition, but of true wisdom.

You are opening their minds to the reception of divine knowledge, thus enabling them to make right progress over paths which will not have to be retraced.

You are doing even more than all this. You are vindicating the "Ways of God to man." You are opening the book of nature, sealed heretofore with seven seals, written within and without, and exposing to view its heavenly teachings; showing to timid souls that occult natural law, the better it is understood, but exalts the more "Him who is all in all."

One of the incidental uses of your admirable Association is its influence upon the young men and women of our land. You popularize science, so that those who are coming after us will more and more feel the force of your example and more and more will follow it.

We are not unmindful of the fact, Mr. President and Gentlemen, that Portland has been indebted to members of your Association more than once for important services. We have in mind an illustration directly to the point, which I beg leave to state. A commission, consisting of Prof. Pierce (Superintendent of the United

Coast Survey), and Professors Mitchell and Whiting, chiefs of the departments of Hydrography and Topography, respectively, have just completed an important scientific work on our harbor, of the greatest consequence to our city, and to such other sections of our country as are benefited by the use of and interested in the preservation of that harbor in its present capacity. From a system of observations upon its currents, and a careful inspection of the material which constitutes its banks and bed, they have told us precisely what we must do to be saved from its deterioration or destruction as a first-class port. The problem they have worked out is one purely scientific and the preservation of our harbor, if we follow their instructions, becomes a certainty. Every foot of water territory and of flats, that it is safe to occupy and turn into productive real estate, they have given us, reserving the rest for the benefit of commerce, thus harmonizing the interests between land and water without waste or sacrifice to either. Here is a direct utilization of the highest kinds of science, such as your Association are pursuing.

We have welcomed you to Portland with somewhat of excusable pride in its harbor, its bay, its islands, its surrounding mountains, and its free and healthful air; an excusable pride because we show it to you as God, the author of all beautiful things, made it, and not we ourselves. You have come to a state which borders the eastern extremity of the continent, and is known more by its location and its limited productions, than by historical renown. Yet, let me remind you, ladies and gentlemen, that Maine was originally a part of Massachusetts, and whatever of honor belongs to that ancient commonwealth belongs in part to us. We have absorbed much of her ideas of religion, education, law and morals, improving thereon, we hope, as occasion might offer.

Maine presents the largest water power, probably, on this continent. Its bosom is laden and almost bursting with mineral values. Its soil is rich, and its fields team with cereal wealth; and the time is rapidly approaching when we shall be able to satisfy the most skeptical that Plymouth Rock has no just claim to its historical eminence, but that on the shores of Maine, people of England landed and settled years before the keel of the Mayflower was cut from the forest.

Mr. President, I renew the words of welcome with which I commenced. I assure you that the citizens of Portland will do all in

their power to make your visit agreeable, and I trust that when you leave us it will be only with pleasant memories.

President Lovering replied in behalf of the Association as follows:

Mr. Mayor: The stupendous pendulum of this Association, weighted with its heavy load of members, in its annual oscillation backward and forward over the continent, from Canada to South Carolina, from the rock-bound shores of New England to the western prairies, has at last in its ever-lengthening swing reached the most easterly state of the Union; and the day may not be very remote, when, in one of its westerly movements, it shall touch the Pacific. After cooling ourselves one year with the bracing air of the Atlantic, or the refreshing breezes of our northern lakes, we have gained courage to bask under the hot skies of some western city; but we have always found there one thing warmer than its burning sun, and that was the great heart of the people by whom we were welcomed and entertained. For the present, we congratulate ourselves that by the kindness and hospitality of the citizens of Portland, prompt to second the wishes of the Association and of its Standing Committee, we are assembled in this polished and elegant city, and in a neighborhood which has no rival, if indeed it has its peer, for natural scenery of mountain and sea-view, of rocks and beach, of lakes, rivers and sea-girt islands.

The circular of your Local Committee has given us a foretaste of the rich and varied banquet which has been prepared to feed our intellects and to gratify our tastes. We are within easy reach of mountains of unutterable grandeur, the glacier scratchings upon whose backs neither time nor any convulsion of nature can obliterate, and which will charm us all equally, though in a different way, whether we go to them with the hammer of the geologist or without it. A few hours' journey, by sail or steam, over waters themselves phosphorescent with wonderful life, will bring us to spots where we may examine for ourselves the dredgings of the deep sea, as they arise fresh from their home in the waters. Should we have time to venture farther from our place of meeting, we may visit that wonder of nature, Mt. Desert, where mountains nearly 2000 feet high dip almost into the sea; where ocean and mountain scenery mingle in strange confusion, and ocean and

mountain breezes mix every year an exhilarating draught for a thousand delighted visitors. To crown all the beauty and sublimity of the spot, the aurora, with almost arctic frequency, shoots up its tinted beams from the northern horizon or springs a bow of silver light across the sky from east to west. The circular of the Local Committee informs us that ample provision has been made for excursions, by land or water, to many of these interesting places, more even than the time allotted to one of our meetings, and the other objects of the Association, may allow us to enjoy.

I said, the other objects of this Association. Let me add that this Association has but one object, and that is proclaimed upon the title-page of its Proceedings. It is the Advancement of Science in this great country. The Association now comprises a constituency of more than 500 members. Few of us can aspire to the honor of being discoverers of the laws of nature, in the high sense of that phrase. But no one, however humble his capacities, or however limited his opportunities, who labors for science, will fail to advance it and be rewarded by it. We meet together from year to year, the veterans in science, with the younger aspirants for distinction, and many more who long to catch the earliest tidings of the last word which science has to say in regard to the earth under our feet or the stars above us; a few to speak but many more to listen, but each doing his part to advance science, either by active research or encouraging sympathy. Our brief meetings allow us no leisure to listen to what is old or to what may be read in books, or to glittering generalities or ingenious speculations on the universe, unsupported by evidence and individual investigation. But any new fact, however microscopic, any new investigation, whether it concerns a planet or an atom, any new experiment by which a law of nature is made more palpable and convincing, finds with us a ready welcome.

We leave to other Associations the business of diffusing knowledge among men. The press, with its thousand arms and its million tongues, can do it better than any Association. Neither do we concern ourselves with the utility of the truths which are communicated at these meetings. If they have no immediate practical application it is sufficient for us that they are true and reveal the plans of the Creator. If they have any commercial value there are men enough in the community to profit by them. It is impossible for the man of science to serve two masters, the Kingdom of

Nature and Mammon. It is a dangerous thing for him to be thinking of the utility of his discoveries or of the pecuniary profit which may be made out of them. The study of the money market unfits him for communion with nature. When Faraday found that alluring avenues were opening before him by which he could easily amass a fortune, he abandoned all semi-scientific avocations, and surrendered himself, unreservedly, to his high calling. In this way he made science honorable and honored. Thus he was able to hold an imperial sway over the hearts and intellects of his generation, and when he bade a final farewell to the laboratory of the Royal Institution of Great Britain, on the 20th of June, 1862, his relinquishment of active scientific work was followed by one universal pang of grief throughout the world of science. We can sympathize with the sentiment of Tyndall in giving his reluctant consent that the narrow quarters and restricted appointments of this Institution, made sacred, as they were, by the labors of Young, Davy and Faraday, should be dismantled, even though they were to be renovated and enlarged in order to provide material accommodation for that vast horizon of truth which his revered predecessors had done so much to open up to the human mind.

Eripuit fulmen cœlis, sceptrumque tyrannis is a fine phrase to catch the public ear. But it is not the lightning-rod which has made the name of Franklin immortal in science, but his experimental researches in electricity, and the theoretical conclusions which he built upon them. Davy's device to protect the copper sheathing of vessels, and even his safety-lamp, may be for various reasons of doubtful utility; the studied and almost theatrical eloquence with which he expounded his discoveries before fashionable audiences in London may be forgotten; but the solid contributions which he made to our knowledge of physics and chemistry will be remembered as long as human language shall be read and understood.

I would not say a word to depreciate the merits of the men who are striving to render science subservient to the conveniences and elegances of life, and to make the homes of the poor more comfortable and even more luxurious than were formerly the palaces of princes. All honor to the inventors of the human race who have followed close upon the heels of the discoverer, and have harnessed the forces of nature, gravity, chemical action, light, heat, electricity and magnetism, to their curious and multiform

machines. But their merits are sure, sooner or later, to be recognized. For all the labor of their brains, for all their anxious waiting and watching, for all their long delay and disappointment, they have their exceeding great reward. The benefits which they confer upon mankind are too obvious to be overlooked, and too marketable to be underestimated. But the foundation of all these manifold inventions is laid, under ground and out of sight perhaps, in scientific investigations into the laws of nature. While we admire the height and beauty of the pinnacle, let us not forget the corner-stone, however old, or unhewn, or unsightly. There never could have been a Morse, a Wheatstone or a Steinheil, unless there had first been a Henry, a Faraday, a Volta and a Franklin.

In this country, where fortunes are so rapidly made and so profusely spent, where material splendor dazzles and bewilders, where the discoverer of comets and planets must look to the King of Denmark or to the French Academy, and not to his own country, for the laurels which he wears, the temptation is strong to forsake the uncompensating labors of severe investigation for the cash payments of practical science. Nevertheless, there are men among us, and they are more numerous than the remarks of Mr. Tyndall in New York would seem to imply, mathematicians, physicists, chemists, geologists, botanists, zoölogists, who pursue science for the love of science: and these men are the pride and glory of this Association. What was said of one such man may be said of all of them. "The world hears but little of them at the time, they neither strive nor cry in the streets, but their labors remain as imperishable as the genius which inspires them."

Because the Association is dedicated to this high object, because a goodly portion of its members devote their lives to the disinterested pursuit of truth, and because the results of their researches not only ennoble their authors, but react upon the community to elevate its tone of thought and to enlarge the compass of its knowledge, this Association has been received with open arms by the best men in every community which it has visited.

And, Mr. Mayor, the welcome which has now been extended to us so cordially and so gracefully by your predecessor, Judge Kingsbury, and the hospitalities which have been so lavishly proffered to us, we receive as a recognition of the nobility of our aims, however frequent our shortcomings in practice, and also as

a stimulus to the better fulfilment of our mission in the future. The enterprise of your citizens, displayed not merely in building railroads and establishing lines of ocean-steamers, but also in founding schools and colleges; the magnificence of your harbor, rivalling, if not surpassing, those of London or Liverpool; the fame of your judges and lawyers, of your physicians and clergymen; the reputation of your men of science and literature, of your statesmen, orators and historians, is well known to us. And this grand greeting which we have just received assures us that there are also here an intelligent appreciation of high pursuits and an exalted public spirit, which fires have not been able to burn out nor many waters to quench.

We of Massachusetts, who are present at this meeting, expected to find ourselves at home among you. We remembered the words which a Governor of Massachusetts uttered when Maine first sprang into independent existence and took her place at the head of the roll-call of the States, and which have been repeated in substance in the address of welcome:—Is she not bone of our bone and flesh of our flesh? And I am sure that those of our number who have come from very distant abodes, and from beyond the limits of the Union, will feel before they leave you that there are no aliens in science: that those who live the farthest apart may be the nearest in their intellectual aspirations: that we are a united people in our love of truth as we now, happily, are also in our institutions.

Remarks were then made by Hon. J. H. Drummond of Portland, Hon. L. H. Morgan of Rochester, Dr. J. W. Dawson of Montreal, Prof. James Hall of Albany, Mr. W. W. Wheildon of Concord, and others.

At the daily general sessions considerable business was transacted, and on the recommendation of the Standing Committee several resolutions were passed, and special committees appointed, as elsewhere given. The committee on a revision of the constitution reported and were discharged. Their report was accepted, and the Permanent Secretary was ordered to print the same and distribute a copy to each member of the Association.

At a general session on Thursday evening, the paper by Mr. Hough on the Preservation of Forests, and that by Mr. Morgan

on the Architecture of the American Aborigines, were read by special assignment.

The general session of Friday evening was especially assigned for the delivery of the Address of the retiring President, but on opening the session President Lovering read the following letter, announcing the donation of one thousand dollars from Mrs. Elizabeth Thompson of New York:—

PORTLAND, Aug. 22, 1873.

Mrs. Elizabeth Thompson of New York City, to-day elected a member, sympathizing with the purposes of our Association in the advancement of science, and seeing the new crop of young and industrious scientific investigators who are to form the future basis of this Association following in the footsteps of the veterans of science who founded it, and being aware of the financial difficulties which often beset the path of those noble men of science who labor more for truth than for profit's sake, wishes to place at the disposal of the Permanent Secretary the sum of one thousand dollars, to be used according to the directions of the Standing Committee, for the promotion and publication of such original investigations by members of the Association as may be accepted by the said Standing Committee, to be published by means of this special donation.

[Signed] P. H. VAN DER WEYDE.

To the Standing Committee of the American
Association for the Advancement of Science.

The President, after alluding to this first considerable donation to the Association, offered, in behalf of the Standing Committee, the following resolutions:—

Resolved: That the thanks of the Association be presented to Mrs. Elizabeth Thompson, of New York City, for her noble gift of one thousand dollars, and equally for her well expressed sympathy with the grand object of this Association, viz., the encouragement of original investigations into the laws of nature, and the publication of their approved results.

Prof. Alexis Caswell, in seconding the resolution, referred to the need of science for such assistance—science, whose benefits know no limits of race, locality, or religion. He spoke of the arduous labors of scientific investigation, and the advantages of the combination of endeavor to promote it by the Association. This donation is a stimulus to renewed effort, purely for the love of truth; it is sowing the seed which shall bring forth such a harvest.

Prof. James Hall in endorsing the resolution related the early history of the Association, and stated how such aid, as was now for the first time bestowed, was needed by the Association to encourage the members in their work. He hoped that the day was not far distant when the American Association would be able, like the British Association, to announce that thousands of dollars were received for the promotion of original research. He was gratified that a lady had set the example here, and that we were able to welcome a lady as the first patron of the Association.

Appropriate remarks were also made by Dr. Van der Weyde, who acted as Mrs. Thompson's agent, and the resolution of the Standing Committee, thanking Mrs. Thompson for her generous donation, was adopted with much enthusiasm.

The following letter was read by General Secretary White:—

To the Members of the American Association for the Advancement of Science:

It is with deep regret that I find myself forced by circumstances to be absent from you on this occasion, and consequently to be deprived of the honor of meeting my fellow associates in Portland, whose hospitable people have assured to us so hearty a welcome in their midst.

I must say, however, though absent in the body, I am present in the spirit, whether in your serious sessions, your social gatherings, or while engaged in unfolding that mysterious compound of *Algæ cum Mya arenaria*, called a clam-bake.

I hope to be engaged in the pursuit of science on the other side of the Atlantic, only a cable's length from you, and if at any time the Standing Committee desire to consult me I am at their service at a moment's notice.

I accompany this communication with an address, which I have requested the Secretary to have read to the Association.

With many good wishes of a profitable meeting and many thanks to the gentlemen and ladies of Portland, especially the latter,

I remain yours respectfully,

J. Lawrence Smith, *President.*

Mr. F. W. Putnam, by request of the Standing Committee, then read the address of President Smith, which is printed in full in the usual place in this volume.

On Saturday Section B resolved itself into two subsections and closed its sessions on Tuesday morning. Section A also formed

a subsection on Monday and closed in the evening. It is greatly to be regretted that the closing days of the meetings are generally characterized by a "rush" to get through with the papers and the consequently rapid organization of subsections, not always done in strict accordance with the rules of the Association.*

At the close of the sessions of Section A, an informal meeting was held by the chemists to consider the matter of a proper organization of a chemical subsection at the next meeting, and resolutions were adopted to be presented to the Standing Committee at the Hartford Meeting.

Much interest was also evinced by the entomologists present at Portland, and several informal meetings were held for the purpose of devising means for securing attendance of a much larger number of entomologists at the future meetings. After due consideration, the following memorial and resolution were formed, signed by all the entomologists present, and received the endorsement of the Standing Committee of the Association:—

We, the undersigned, entomologists, assembled at the twenty-second meeting of the American Association for the Advancement of Science held in the city of Portland, in August, 1873, hereby respectfully petition the American Entomological Society of Philadelphia, and the Entomological Society of Canada, to appoint yearly meetings of their members to be held at the same times and places with the annual meetings of the American Association for the Advancement of Science. The undersigned are moved to this memorial from the consideration that such prospective action on the part of the American and Canadian Entomological Societies would ensure the annual assemblage of a large

* If the Sectional Committees, after a careful survey of the list of papers placed in their hands, would report on the second day regarding the organization of such subsections for the following days as they think will be necessary, in order to allow all the papers to be duly read and discussed, they would have time to prepare their programmes properly, and members and others interested in special papers would be able to ascertain the time and place of their delivery, which are the principal objects in printing the daily programmes. Should the new Constitution, as proposed at Portland, be adopted it is believed that much confusion will be avoided at future meetings, especially if the members of the sections will bear in mind the importance of the Sectional Committees. These Committees are, in fact, the safeguards of the Association, and to them is intrusted the arrangement of the programmes of the sections and subsections, and they alone are responsible for the proper order of the business and of the scientific reputation of the sections. With these grave responsibilities, it is certainly of the most vital importance for the welfare of the Association that the Sectional Committees should be most carefully selected from those members who can remain throughout the meeting.

number of entomologists, resident over a wide extent of territory, and also practically enlarge the sphere and increase the usefulness of the societies.

[Signed by J. L. LeConte, Chairman, P. R. Uhler, Secretary, and fourteen other entomologists, members of the Association.]

Resolved: That the American Association for the Advancement of Science hereby endorses the accompanying memorial, and invites the American and Canadian Entomological Societies to call yearly meetings of their members in accordance with the request therein contained.

Adopted by the Standing Committee, August 26, 1873.
C. A. White, General Secretary.

During the week of the meeting, and for several days after the adjournment, a number of entertainments and excursions were given for the benefit of the members of the Association. These entertainments are always productive of much good fellowship between members and the citizens with whom they are thus brought in immediate social relations, and they produce the best of results, not only to the Association but to the citizens of the place, while they invariably furnish the means of obtaining practical information on many scientific points.

The lunch given by the ladies of Portland on Friday noon was a very enjoyable entertainment, and had it come at an earlier day in the meeting, it would have added still greater pleasure to the members by the longer continuance of such pleasant acquaintance as was then made with so many of the élite of the city.

On Tuesday afternoon a very pleasant, and to many of the members a very novel, entertainment was furnished by the excursion to Old Orchard Beach with its accompanying clam-bake. This excursion was very largely attended, nearly every member and a very large number of citizens enjoying the hospitalities extended by the Local Committee.

On Saturday afternoon a large number of members accepted the invitation for an excursion in Casco Bay, in the United States Revenue Steamer McCulloch. After the adjournment of the meeting, several more extended excursions were enjoyed by members and citizens. On Wednesday, by invitation of the Portland and Ogdensburg Railroad Company, nearly all the members present made a trip to the White Mountains, going as far as

Upper Bartlett. The majority returned to Portland at night, but very liberal arrangements having been made by the Local Committee for those who wished to remain and make the ascent of Mt. Washington, some sixty members availed themselves of the opportunity and returned to Portland on Thursday night.

On Friday the Revenue Steamer was again placed at the disposal of members for a dredging excursion to be conducted under the management of the gentlemen connected with the U. S. Commissioner of Fisheries, and a very instructive lesson in deep sea dredging was obtained.

During the meeting of the Association and for the week following the adjournment, frequent visits were made by individual members to the head-quarters of Prof. Baird, the U. S. Commissioner of Fisheries, which were located for the season on Peak's Island, and were easily accessible by steamer from Portland. These visits, in connection with the Aquaria maintained with much labor by Mr. Charles B. Fuller in the rooms of the Portland Society of Natural History, enabled the naturalists residing at a distance from the sea-coast to become acquainted with a large number of forms of animal life that they had never before seen in a living state, while the collections that had been made by the Fish Commissioners, and the finely arranged local collection in the Portland Society of Natural History, must have furnished many members of the Association with their first sight at very interesting marine forms.

The excursions were closed by the extended one to St. John and Fredericton. On Friday night some fourteen members under the charge of T. C. Hersey, Esq., President of the International Steamship Company, took the steamer for St. John, where they arrived on Saturday night. On Monday morning, by invitation of the Messrs. Lunt, the party went to Fredericton, and returned to Portland on the following Thursday after a very pleasant trip for which they were deeply indebted to their kind entertainers.

On Tuesday morning, August 26, the sections having finished the business before them by early sessions of the subsections of Section B, the general session was called to order. On recommendation of the Standing Committee the invitation conveyed in the following letter, which was read by President Lovering, was accepted.

Portland, Aug. 25, 1873.

Prof. JOSEPH LOVERING, Pres't *Am. Scientific Association*.

Dear Sir: I am requested by the Hon. Henry C. Robinson, Mayor of the city of Hartford, Conn., to extend to this Association an invitation to hold its next Annual Meeting in that city, and I most cordially join with him in extending the invitation.

Respectfully yours,

J. M. ALLEN.

It was then voted to hold the twenty-third meeting of the Association at Hartford, Conn., commencing on the second Wednesday of August, 1874.

The following officers were then elected for the next meeting: *President*, J. L. LECONTE, of Philadelphia; *Vice President*, C. S. LYMAN, of New Haven; *General Secretary*, A. C. HAMLIN, of Bangor; *Treasurer*, WILLIAM S. VAUX, of Philadelphia.*

Votes of thanks to various parties to whom the Association was specially indebted were then adopted, with appropriate remarks from members, and at 11 o'clock President Lovering closed the meeting in the following terms:—

Gentlemen and Ladies of the Association:—The hours of this meeting are rapidly passing and the time which remains can be counted in minutes. It is fit, therefore, that I should detain you with the fewest possible words at parting. Allow me to congratulate you on this large and prosperous meeting as now a fact accomplished. I think that you will all be willing to supplement, at least in your memory and your hearts, the formal expression of thanks which have been voted, by a grateful though silent recognition of the favor conferred on the Association by those eminent naturalists who have left their work in the field, at this precious season of the year, and have hurried hither at the call of this meeting. For myself, I feel that we owe a large debt of gratitude to our great mathematician in that he has not excused himself from attendance on our annual gathering in consequence of his numerous and heavy responsibilities as Superintendent of the United States Coast Survey, but has lent us his inspiring voice and intellect. We thank the distinguished Secretary of the Smithsonian Institution for his commanding presence with us before our adjournment. Especially, do we thank our friends

* The Permanent Secretary holds office from his former election for two years.

from Canada for the intellectual strength they have given to this meeting. Others in both Sections, whose names will readily occur to you, we could have wished to hear ourselves and to introduce to the citizens of Portland, if they had found it convenient to be present on this occasion.

While we thus honor our great men among the living, both present and absent, we will not forget our illustrious dead. Genial faces like that of Foster will no more gladden our hearts at these meetings. Eloquent voices like that of Perry will never again be heard in our sections. Venerable forms, like those of Coffin and Torrey have disappeared and will be seen no more on earth to excite our emulation and awaken our reverence. But we will not be discouraged; much less will we despair. Rather will we seek the symbol of this Association in the heaven of stars, where, indeed, sun after sun doth continually sink below the western horizon, to be replaced, however, by a whole galaxy of light which is rising in the east. Can we not expect, may we not demand, of the young men of the Association, that for every single luminary which we lose, a double, triple, and even sextuple star shall arise to make the firmament of science even brighter than it was before?

I am not unmindful of the generous votes of thanks which you have passed to the officers of the Association: very flattering in my case, but fully deserved by your secretaries. I have had the easy work of pulling the little ropes at the helm, while they have worked the laboring oars, and must now handle the heavy cable which shall give the Association a safe anchorage during the interval between this meeting and the next.

There is always one word harder than all others to speak and that is the last word. But our hour has come: our work has been done as best we could do it, and it only remains for me, after wishing you a safe return to your friends and your homes, and a reappearance, when the Association, without loss of material or brightness, makes its next perihelion passage, to pronounce this meeting at an end.

RESOLUTIONS ADOPTED.

Resolved, That the American Association for the Advancement of Science has learned with high satisfaction that the Congress of the United States, at its last session, in accordance with a recommendation of the President of the United States in his Inaugural Message, has extended to the INTERNATIONAL STATISTICAL CONGRESS an invitation to hold its next session in this country, and this Association hereby expresses its earnest hope that the invitation thus cordially extended will be accepted by the Permanent Committee of the Congress.

Resolved, That a Committee be appointed by the Association to memorialize Congress and the several State Legislatures upon the importance of promoting the cultivation of timber and the preservation of forests, and to recommend proper legislation for securing these objects.

Whereas, The object of this Association is the general advancement of Science, and as one of the most powerful means of promoting it is the extension and increased efficiency of scientific education; and as, moreover, there is a growing interest in this subject on the part of teachers and educational boards, and much embarrassment and many inquiries as to the best methods of attaining the object; and as, furthermore, a deliberate expression from this body in relation to the question would have great weight with those asking for guidance; therefore

Resolved, That a Committee be appointed by the Chairman to take this subject into consideration and report at the next meeting of the Association upon the most desirable methods of scientific study for primary, common and high schools; pointing out the sciences that are most desirable to be studied in those institutions in their actual phenomena, the time that should be allotted to them and the order in which they should be pursued, and making such other recommendations regarding the subject as in the opinion of the Association will be conducive to the general interest of science.

VOTES OF THANKS.

Resolved, That the thanks of this Association be presented to the Chairman, Hon. Benj. Kingsbury, Jr., his honor Mayor Westcott, the Secretary, Rev. Charles W. Hayes (whose labors have been indefatigable and unremitted in our behalf) and all the members of the Local Committee, for their especial and successful arrangements and efforts in behalf of the Association at its present meeting in this city; regarding these as not simply complimentary to the members of the Association, but as indicating their appreciation of its high purpose, the Advancement of Science.

Resolved, That the thanks of the Association be specially tendered to his honor the Mayor and members of the City Council for the free use of the admirable and very commodious apartments of the City Hall for the use of the Association during its present meeting; and to the citizens of Portland generally for many attentions and kindnesses tendered and bestowed upon its members.

Resolved, That this Association recognizes with pride and satisfaction the interest which the ladies of Portland, as of the whole country wherever our Association has held its meetings, have manifested in the advancement of science; and to them belongs, by the thoughtfulness and generosity of one of their sex, the distinguished honor of making the first substantial contribution to its means, and laying the foundation of its permanency and continued usefulness.

Resolved, That our especial thanks are hereby tendered to the ladies of Portland for their elegant and hospitable reception and lunch given to our members and ladies at Congress Hall, on Friday, 22d inst., the pleasure and social enjoyments of which were so much enhanced by their presence, their generous welcome and unwearied attention.

Resolved, That the thanks of the Association be tendered to Mr. C. B. Fuller, the curator of the Portland Natural History Society, for his courteous and unwearied attention to the wants of the members in accommodations rendered in connection with the Museum of which he has charge.

Resolved, That the thanks of the Association be presented to the managers of the Portland and Odgensburg Railroad for their invitation to visit the White Mountain region at Upper Bartlett and return. Also to the Boston and Maine Railroad, the Eastern Railroad, the Grand Junction Railroad, and other railroads mentioned in the circular of the Local Committee, for reduction of fares in favor of the members attending the meeting of the Association. Also to the Portland Steam Packet Company, the Maine Steamship Company, the International Steamship Company, and the proprietors of the New England and Nova Scotia Steamships for similar privileges—all in behalf of the objects of this Association.

Resolved, That the thanks of the Association be presented to Ex Gov. Israel Washburn, Collector of the port, Lewis B. Smith, Esq., Deputy Collector, and to Captain Treadwell, commander of the Revenue Cutter McCulloch, for the tender and use of that vessel in our very delightful and invigorating excursion in the harbor and through Casco Bay, on Saturday afternoon, 23d inst., which proved so pleasant and gratifying to all our members and the ladies accompanying them.

Resolved, That the thanks of the Association be tendered to the Superintendent of the Coast Survey, and to the Commander of the U. S. Coast Survey Steamer "Bache" for their courtesy in offering a deep-sea dredging excursion to the members.

Resolved, That the thanks of the Association be tendered to Ex Governor J. L. Chamberlain, President of Bowdoin College, for his polite invitation to visit that institution.

Resolved, That a vote of thanks be presented to the reporters and proprietors of the press for their untiring efforts in presenting the labors of the Association before the public.

Resolved, That the Association tender to the retiring President the expression of its sincere thanks for the ability, courtesy, impartiality and uniform urbanity with which he has presided over and conducted the deliberations of the Association.

Resolved, That the thanks of the Association be given to the retiring General Secretary, Prof. C. A. White, for the ability, courtesy, and diligence with which he has performed the duties of his office.

FINAL REPORT OF THE RETIRING PERMANENT SECRETARY.

This report covers the interval of time between the first day of the Dubuque meeting (August 14, 1872) and the first day of the Portland meeting (August 20, 1873).

During the meeting of the Association the time of the Permanent Secretary is fully occupied, and, after the adjournment, the correspondence foreign and domestic, the collection of assessments, the preparation of the Proceedings for the press, the examination of proof-sheets, the distribution of the volumes at home and abroad, and the arrangements for the next meeting, all make a constantly recurring cycle of duties, only finished to be begun again. After I had completed the printing of the Dubuque Proceedings, the edition was delivered into the hands of my successor, Mr. F. W. Putnam, by whom it was distributed. The arrangements for the Portland meeting, so far as the Permanent Secretary is expected to assist in them, were also made by Mr. Putnam. The other duties of the office were discharged by me until the first day of the Portland meeting. I cannot but repeat my regret that the reputation of the Association, especially before the commonwealth of science in Europe, suffers greatly from the failure of many of the strongest members of the Association to furnish a copy of their valuable communications for the printed Proceedings. On this account our publication is a very inadequate exponent of the scientific resources of the Association.

The financial condition of the Association was never before so prosperous as at the present time.

Between August 14, 1872 and August 20, 1873 the income of the Association was twenty-one hundred and six dollars and ten cents ($2,106.10).

Of this amount, fifty-six dollars and sixty cents ($56.60) accrued from the sale of the printed volumes, and the remainder from the admission fees of new members and the annual assessments.

The expenses of the Association during the same interval amounted to nineteen hundred and nine dollars and twenty-nine cents ($1,909.29), which may be divided thus:

Cost of paper, printing, and binding for the Dubuque Proceedings, ...	$1,109.07
Charges connected with the Dubuque meeting,	114.95
Salary of the Permanent Secretary, . . .	500.00
For circulars, stationery, express, and postage,	135.72
Expense of removing stock to Salem, . .	49.55

The particular items may be found in the cash account of the Permanent Secretary which is herewith submitted as a part of his report.

The balance in favor of the Association amounts, at this date, to nineteen hundred and eighty dollars and twenty-seven cents. Of this sum one thousand dollars was paid over to the Treasurer on Oct. 23, 1871, and has been on interest since that time. Five hundred dollars more was paid over to the Treasurer on August 25, 1873, and has been put out to interest. The remaining portion of the balance, amounting to four hundred and eighty dollars and twenty-seven cents, has been passed, by order of the Standing Committee, to my successor, Mr. F. W. Putnam.

When the undersigned entered upon his duties at the eighth meeting of the Association, it had an annual income of only a few hundred dollars and was dependent upon the generosity of the cities where it met for the publication of its Proceedings. Since that time it has been able to pay all its expenses, owns a valuable stock of Proceedings, and possesses a cash balance amounting (with interest) to more than two thousand dollars. Its present financial prosperity is due to that change in the Constitution by which new members are required to pay an admission fee in addition to the annual assessment.

JOSEPH LOVERING,

Retiring Permanent Secretary.

Portland, August 20, 1873.

CASH ACCOUNT OF THE

Dr. AMERICAN ASSOCIATION IN

E. D. Cook's bill as assistant secretary	$30 00
Printing circulars	9 75
Telegraph to Portland from Dubuque	9 95
Postage and discount on draft	64 29
Woodcuts for Dubuque volume, &c.	80 00
Printing of Dubuque "Proceedings"	1,003 07
Binding of Dubuque "Proceedings"	44 10
Expense of distributing Dubuque "Proceedings"	57 04
Sawin, for freight	30 54
American Naturalists' Agency for Dr. Hunt's extras	26 00
Charges for removing stock to Salem	49 55
Salary of Permanent Secretary	500 00
Stationery	5 00
	$1,909 29
Paid to the Treasurer	1,000 00
Paid to the Treasurer	500 00
Paid to F. W. Putnam	372 00
Paid to F. W. Putnam	108 27
	$3,889 56

PERMANENT SECRETARY.

ACCOUNT WITH JOSEPH LOVERING. Cr.

Balance from last account	$1,782 46
Assessments from 785 to 1192 inclusive (including money received for sale of Proceedings)	2,106 10
Error in cash account of August, 1868	1 00
	$3,889 56

STOCK ACCOUNT OF THE PERMANENT SECRETARY.

The present Permanent Secretary has received, from his predecessor in office, the stock of volumes of Proceedings, the Library, and various documents belonging to the Association, and they are now most conveniently arranged and safely stored in a room on the first floor of the Museum building of the Peabody Academy of Science. This room is in charge of a special assistant and is devoted to the use of the Association as the office of the Permanent Secretary.

The volumes, parts of volumes, and pamphlets, forming the library belonging to the Association, have been catalogued and arranged.

The total number of copies of Proceedings, including the volume of "Transactions of the American Association of Geologists and Naturalists," and the twenty-one volumes of the "Proceedings of the American Association for the Advancement of Science" received from the retiring Secretary, amounted to eleven thousand two hundred and eighty-two.

Five hundred and sixty-two copies of the Dubuque volume and fifty-seven copies of preceding volumes have been distributed to members who were entitled to them. Fifty-nine copies have been distributed by votes of the Standing Committee to American Institutions, and one hundred and twenty to Foreign Societies and Institutions in exchange for their publications. The list of Foreign Societies published in the Dubuque volume was, with a few changes, followed in sending out the volume. Two hundred and fourteen copies of various volumes have been sold, leaving a balance on hand at this date of ten thousand two hundred and seventy copies.

F. W. Putnam,

Permanent Secretary.

Salem, September 1, 1873.

APPENDIX

TO THE

HISTORY OF THE MEETING AT PORTLAND,

BY

WILLIAM W. WHEILDON OF CONCORD, MASS.

THE meeting of the American Association at Portland forms an era in its history, not so much from the fact that it had then completed its twenty-first year of active life, but rather that measures were there inaugurated for its permanent legal existence and a foundation laid for the enlargement of its purposes and more extended usefulness.

When we look back at the organization of this Association in 1848, by gentlemen devoted to the study and pursuit of a single branch of science, and that branch comparatively new, we have great reason for congratulation in view of its continued prosperity and its present acknowledged position. It has gone on from year to year in increasing usefulness, gradually drawing into its ranks gentlemen of intellect and energy, of learning and genius, in every branch of science and natural history; and includes to-day an ample membership to sustain its position and worthy of its high purposes. Of the original members of the Association of Geologists who formed the nucleus of this Association at Philadelphia, only three now remain to witness its prosperity, and of these only one, Prof. JAMES HALL of Albany, was present at Portland. The meeting, however, was largely attended and many members contributed interesting and valuable papers at its sessions. The evening sessions in the City Hall were very fully attended by the citizens of Portland, and were eminently successful in entertainment and in interest. The general sessions and those of the sections during the day were always well attended, and the discussions which followed the reading of many of the papers were interesting and attractive.

SCIENTIFIC DISCUSSIONS.—At some of our recent meetings it has been spoken of as a matter of regret that these discussions were not properly reported for publication in connection with the papers which called them forth, and there is a general desire that this deficiency may be provided for in the future meetings of the Association. Scientific discussions, although sometimes exciting and earnest, are rarely personal and still more rarely discourteous or unseemly. Differences in opinion often arise and as they are supposed to be based upon evidence or reason, they are

not readily given up; and as evidence itself is seen in different light under different circumstances, with divers powers of generalization, or with certain convictions and preconceived notions, it is not surprising that opinions, however adverse, should be adhered to with considerable, and it is to be hoped, considerate pertinacity. Yet where truth alone is the object, however much opposing parties may desire to establish their own opinions, when that is reached and made manifest, the triumph is a gain to science and not to either party. The very differences may and it is almost certain must have been instrumental in reaching the result attained, so that it is not unreasonable, nor in fact undesirable, that different opinions should exist in the consideration of scientific problems, so that they be well considered, courteously maintained and kept subordinate to the great purposes of science. In this way and in this way only, can harmonious action be preserved and the best results attained. It is gratifying to be able to say that these sentiments have prevailed at all the meetings of our Association.

EXCURSIONS OF THE ASSOCIATION IN IOWA.—Several very interesting scientific excursions were made by members of the Association during the meeting at Portland. These at a distance have been the subject of remark and sometimes spoken of in the ordinary sense of excursions of pleasure; but this is incorrect. They are not simply pleasure trips, but quite the reverse and have an eminently practical and useful purpose, and this is never lost sight of, nor the advantages afforded for observation and collection ever overlooked or omitted. Take for example the excursions of the meeting preceding this, from Dubuque, which were eminently scientific. They were first to the lead mines and were truly laborious; only redeemed from unpleasantness by their scientific character. The excursion up the Mississippi River to McGregor was prominently for scientific as well as social purposes; and one of the most interesting objects ever visited by the members of the Association was the remarkable sandstone rift on the western shore of the Upper Mississippi; and at the same time the Wisconsin shore was visited in order to obtain botanical specimens peculiar to that locality. These things, in fact, were the attractive objects of the excursion, and while they were amply compensating, the public entertainment provided by the ladies of McGregor crowned with pleasure and festooned with delightful recollections, one of the most satisfactory excursions ever made by the Association.

So also of the much longer excursion which followed, across the State of Iowa, which was participated in by some forty members. It was full of scientific purpose and accomplishment, and in both respects yielded full compensation to science as well as recreation. Nor are the benefits of such an excursion as this confined to the excursionists, or even to those with whom they come in contact. By reference to the narrative of the excursion spoken of it will be seen, not only what opportunities the party enjoyed for scientific observation and exploration, in

various departments of natural history, but also what service they rendered in answering numerous inquiries, in discussions, and comparisons, and yet more prominently in public lectures given by the members before crowded and interested audiences. It is not too much to say that in all the communities where stops were made and in all the places visited, there was a mutual benefit between the people and the excursionists and a clear gain for science. Science as a pursuit or science as a recreation was almost unknown, if not in fact unheard of, in some of the remote settlements visited by this party; and it was a new thing to see gentlemen and ladies collecting specimens of rocks, coal or other minerals, and catching insects, searching the prairies for plants, seining the rivers for fish, and carefully preserving these in boxes and bottles. Interest was everywhere excited in the party and its movements, and especially in its acquisitions; and it is very certain that the lesson afforded by these things was not lost in a scientific sense, and the visits and explorations made were eminently successful in their social aspects.

Excursions from Portland.—We might refer to other excursions made by the Association and its members, in order to show their scientific character and purpose; those from Portland especially, which are spoken of in the present volume. The first one in Casco Bay was extremely interesting, and especially so to a number of members from the far west who on this occasion made their first acquaintance with salt water and the sea, and who were specially enthusiastic over the beauty and majesty of the blue ocean, the tossing waves, the rolling breakers, the long beaches and what they found there in their native habitats. There was also scientific interest as well as novelty in the modern "clam-bake," on the magnificent beach at "Old Orchard," with its historical associations and present attractions. We need scarcely to speak of the excursion to the White Mountain region—so full of interest to all the party; or to that made by sea to St. John, N. B.; or to the dredging expedition, so kindly proffered by the coast survey, along the coast—for these all commended themselves in behalf of science as well as pleasure.

This feature of our Association is neither to be discarded or held in light estimation. It has its purposes, not alone in the advancement of science and in popularizing the work of the Association, but also in its varied social aspects. No higher compliment can be bestowed upon the Association than the tender of opportunities and facilities in the interest of its pursuits, made by persons who appreciate them and who thus manifest their respect for those who labor for their advancement.

Proposition of Incorporation.—But the most important proceedings of the Association, at Portland, were those which relate to its future organization, its permanent legal existence and its enlarged means of usefulness. Having sustained itself for twenty-one years by the annual contributions of its members, and the kindness of the people among whom its meetings have been held, the members were surprised and

gratified by the generous donation of Mrs. Thompson in aid of the objects of the Association, and it has been intimated that other gifts may be expected.

Next to this in importance, and in fact made necessary by it, was the proposition to obtain an act of incorporation, in order that the Association may hold property and manage its financial affairs in a safe and legal manner. The possession of such an act will affect indirectly but largely, the interests and usefulness of the Association, giving to it the dignity of law, the right to receive and hold property for the purposes of the voluntary Association, and other rights and privileges of an incorporated body. The matter of obtaining the charter was placed in the hands of a committee and their report will be presented at the meeting at Hartford.

MEMBERSHIP.—An interesting subject incidental to the future prosperity of the Association is that of membership, which has to some extent been made a topic of remark in print, and in one case "the absence of any definite test of qualification for membership" is deplored. The American Association for the Advancement of Science, like its British compeer, is distinctively a popular institution, and to a great extent leaves the propriety and utility of membership to be decided by the good sense, the judgment and intentions of the applicant. No doubt certain classes are properly described by Dr. Dick when he says—

"Some persons are disposed to consider science and natural history merely as genteel studies; others apply their minds to such subjects with the view of bearing a part in the conferences of men of learning. Some again prosecute such pursuits for the purpose of making collections of scarce and valuable curiosities, and of displaying a degree of knowledge and taste superior to those of their neighbors; and the greater part of mankind consider such studies as only amusement or a relaxation of mind from the fatigues of their daily avocations." "But the study of nature and science," he adds, "is highly dishonored by such grovelling and contracted views. The prospect of the universe was exposed to our view for more noble and exalted purposes—to make us wiser and better men; to expand our views of the perfections of our Creator, and to inspire us with a grateful sense of all the blessings we daily receive from his bountiful hand."

It has never been deemed necessary in acting upon applications for membership for this Association to enter upon the consideration of motives, beyond those which are manifested by the application, or doubt that they are proper and justifiable. It is sufficient for it that the candidate has the endorsement of at least two present members—a measure necessary to bring his name before the Standing Committee. It may or may not be found necessary to change these provisions; but at present they appear to be all that is necessary on the part of the Association and cannot be objected to on the part of applicant.

But there is another consideration; it is not merely the scientific man,

but the friend and lover and patron of science that may claim membership under our rules. These are desired and desirable. Those who, even in middle age, are giving their minds to science, may hope to be aided by joining our Association in the pursuits and investigations which interest them. It may be asked in what way can the Association promote its great purpose — the Advancement of Science —which will be more promising or which is more efficient? It accords with its popular character as it does with its purposes, and is rather a feature to be encouraged than omitted or restricted.

There is another class of members, the accession of which the Association may appear to have encouraged and to some extent has done so. It has at least facilitated the process by allowing membership for one, two or three years; a right, however, practically available to all members by simply neglecting to pay the annual assessment. This class of members is composed of those not pursuing scientific studies and not intending to do so, and who join the Association sometimes doubtless upon the invitation of friends; from a desire to aid the Association by a small contribution to its funds; from mere curiosity or from personal considerations of no importance to the Association. These persons may find it convenient to attend one or more of the meetings of the Association, and very probably then drop off. In this case, which has no doubt frequently occurred, the member may have gained something as well as the Association, and so far both parties are benefited. The practical question in this matter is, Shall the custom be allowed to continue? It may be thought that a large membership will be embarrassing to the business of the meetings; but no inconvenience of this kind has ever been experienced and probably will not be hereafter. Or it may be thought that membership should be confined to persons of scientific attainments, or at least to those who will become active members—and this is the question of vital interest to the Association. For ourselves we should regard such a restriction as very unwise; as fatal to this Association in its popular character, and as a measure entirely adverse to the advancement of science, which is the object of its formation. It needs no argument to show that the adoption of such a rule, which seems to have been looked upon as practicable, will be equivalent to an abandonment of the legitimate purposes of the Association. Such members are unquestionably an advantage to the Association, not merely by their annual contribution to its funds, but in other beneficial ways. They give to it the weight of numbers, much of personal character and influence, and link it very closely with society wherever the Association holds its meetings, and give it public interest and an audience.

Still, there are those who think some discriminations, other than those existing in regard to membership, are desirable, and would be beneficial to the cause of science. We think differently; the wisdom of the original rule commends itself to our judgment, and we do not believe any others, beyond the proper enlargement and expansion of this in the

new constitution, are requisite. The provision for life membership is deserving of especial commendation. Under this clause gentlemen of means and appreciation will have an opportunity to contribute to the purposes of the Association without the annoyance of yearly payments, and may avail themselves of all the privileges of membership at any of its meetings. They may thus add to its character and usefulness and give their approbation to its popular element.

There is also another class—not thorough scientists, but students, devoted it may be to some special department or branch of science—and these may naturally seek the aids which are afforded to them by membership of our Association. We may not look to these for the highest scientific work; but they are pretty sure, sooner or later, to contribute something towards the advancement of science. They are generally young men, on whom higher duties will soon devolve and from whom higher services are to be expected. It may be that they are hereafter to become the leading members of the Association, prepared to sustain its character, advance its growing interests and make international its reputation.

OUR WORKING MEMBERS.—The Association, of course, will know how to appreciate its working members, for to their labors, their skill and their sacrifices, are we to look for the advancement of science. It may well say of them, "These are my jewels," for to their care, interest and effort, is intrusted the scientific character of the American Association, and to some extent that of the country which it represents. So also will it know how to appreciate those friends and patrons of science who are disposed to give their aid to the purposes of the Association, although they may not participate actively in its labors. They are essential to its well-being, necessary to its success, promotive of all its interests, and give to it its distinguishing characteristic as the popular scientific association of the country.

In the broad and popular character of the American Association as we have spoken of it, it is not the rival of any other body, either in purpose or practice, but the helper and co-worker for the promotion of science. It does not pretend to be composed of accomplished scientists only, with a limited number of members; such a claim would be adverse to its principles, an abandonment of its popular character and an impeachment of its usefulness. It still proposes to be open to all, to foster genius, to advance science, to pursue the onward way in the paths it has opened and in fields yet only partially explored.

CONCLUSION.—So that, upon a consideration of all these things, we may not only regard the Portland meeting as forming an era in the history of the Association; but after an experience of twenty-one years, we may look back with interest upon its history and re-affirm the principles and great purposes of its founders. It is in accordance with the spirit of our government and the age, having all its inspiration and sympathies

from the people in its popular character. We say very distinctly let the Association adhere to its purposes and pursue them as heretofore with unabated interest. It is undoubtedly on the high road to prosperity and eminence, and so long as it shall continue in the wisdom of its founders it will be safe from imbecility and indifference. Pursuing a similar course and policy as the British Association, we shall be able to say, as President Sedgwick said before that Association:

"Our meetings have been essentially harmonious only because we have kept within our proper boundaries, confined ourselves to the laws of nature and steered clear of all questions in the decision of which bad passions could have any play. But if we trespass our proper boundaries, go into provinces not belonging to us, and open a door of communication with the dreary wilds of politics, that instant will the foul Demon of Discord find his way into our Eden of Philosophy."

INDEX.

3 gal
174+